CATALOGUE OF
PHYSICAL INSTRUMENTS

L. E. KNOTT
APPARATUS COMPANY
BOSTON

51733

A Catalogue

of

Physical Instruments

Catalogue 17

R. C. Browne.

L. E. Knott Apparatus Company
Boston

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1912

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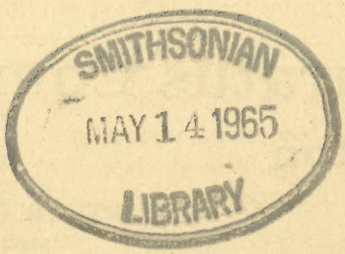

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PREFACE

WE offer in the following pages a series of scientific instruments and a list of physical apparatus which will be found adequate for the study of Physics in the most advanced laboratory. All instructors in science will recall that we are by direct descent the oldest apparatus house in this country, dating back to 1854. We still have with us men who have worked under and were intimately connected with such men as E. S. Ritchie, A. P. Gage, and A. E. Dolbear. Many will recall that it was Mr. E. S. Ritchie whom Professor Tyndall selected to assist him during his American lectures.

The number of this catalogue indicates the number of years that the L. E. Knott Apparatus Company, under its present name, has been in business. During this time it has doubtless equipped more laboratories and furnished more material to colleges and schools than any other house of its line. We therefore feel that we are peculiarly well fitted to offer a catalogue such as this. We ask your consideration of the following pages.

Under each subject we have aimed to include only those pieces best suited for the particular experiment and demonstration. In making this selection from our complete line we have found that it requires even greater judgment to determine what to omit than it does to determine what to include, but unnecessary duplication has been carefully avoided. We realize that the instructor whose duty it is to equip or improve a laboratory should buy only the best and at the same time strive to make his appropriation go as far as possible.

A large proportion of the articles offered have been designed and developed in our own laboratory under the supervision of men whose training and experience have well fitted them for the task. In addition we have made a careful selection from the best scientific establishments of the world. In making the selection we have been guided by numerous suggestions received from our customers, an obligation which we are pleased to acknowledge at this time, with the hope that all of our customers will feel it an obligation as well as a pleasure to favor us with any further suggestions which their experience develops.

We wish to emphasize the fact that in the compiling of this catalogue we have endeavored to make it more than a price-list. The arrangement, we believe, will be found to have been made on a scientific basis, each instrument being classified and appearing in its proper place. We have embodied in our description many valuable suggestions concerning the use of the apparatus on the lecture table and in the laboratory. The illustrations are original, prepared from photographs taken from the completed apparatus itself. Many useful tables have been included and other features added which we feel will give to this work unusual value as a catalogue of scientific instruments.

DIRECTIONS AND TERMS

THIS CATALOGUE SUPERSEDES AND DISPLACES ALL PREVIOUS EDITIONS

CORRESPONDENCE:—Persons writing to us should use an official letter-head whenever possible. If such stationery is not available, kindly advise what institution you are connected with and the position you hold.

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REMITTANCES: — Our terms are net thirty days. We allow a cash discount of 1 per cent from the face of the bill if the check is sent to us within ten days from the date of invoice. Interest at the usual rate is charged for overdue accounts. All remittances should be made in checks payable through the New York or Boston Clearing House. On checks or drafts payable at other points, the proper amount to cover the exchange should be added. School Warrants should be registered and if it be known that no money is immediately available for payment, please advise us when funds will be provided. If local banks are prepared to purchase these warrants at par, the names of such banks should accompany the warrant.

RETURNS: — If for any reason it is desirable to return goods, kindly advise us by mail concerning the conditions so that no misunderstanding may arise. We are always glad to accommodate but we cannot accept or give credit for goods which are returned without previous arrangement having been made.

REPAIRS: — If goods are sent to us for repair, see that the case is properly marked, giving the name of the sender. Send us a letter at the same time stating what you are returning and what you wish to have done to it.

PRICES: — There is no uniform discount which applies to all of the items in this catalogue. We have in almost every instance improved our apparatus very materially. In a great many instances, it will be noticed that we have decreased the catalogue prices. This has made it necessary to fix the discount on most of the apparatus at 10 per cent from catalogue prices. Wherever possible, we have retained our former discount of 20 per cent and such discount will be allowed on many items. On Duty Free apparatus and also on a number of special pieces the catalogue prices are strictly net.

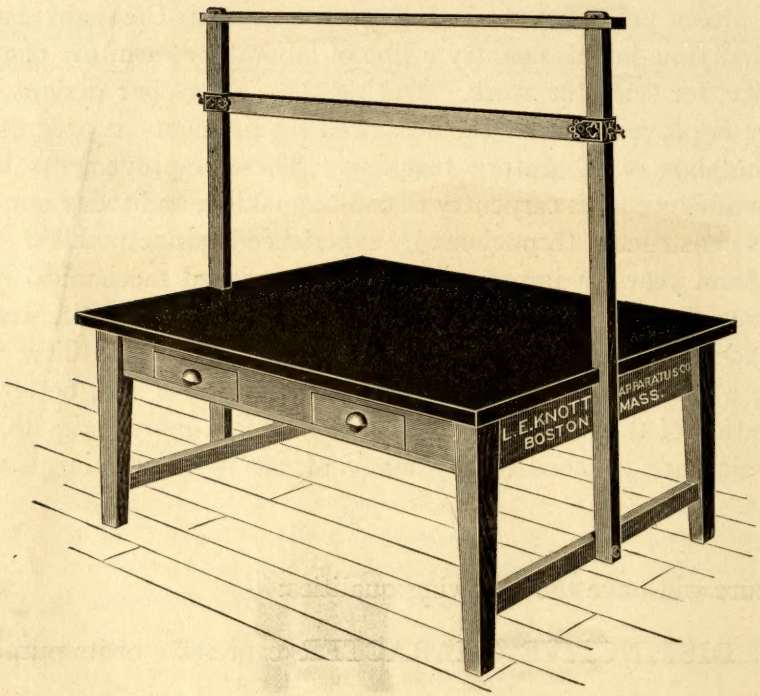
LABORATORY FURNITURE

ABOUT fifteen years ago the L. E. Knott Apparatus Company exploited for the first time in this country a line of laboratory furniture characterized, by its utility, for scientific work. During these years our designs have been successively improved to meet the advanced requirements as progress has been made in methods of laboratory teaching. These improvements have made essential an advance from carpentry to cabinetmaking, and today our laboratory furniture is constructed throughout by experienced cabinetmakers. Resulting, therefore, from years of improvements and improved mechanical methods of manufacture, our line of laboratory furniture meets all scientific requirements and is unexcelled by any line on the market in quality and utility. It will be noted from a study of our illustrations and descriptions and, better still, from an examination of the furniture itself, that we may justly claim the following features which are vouched for by many of the most prominent educational institutions.

Our furniture will have the following qualities:

1. **DISTINCTIVE CHARACTER** expressive of its purpose.
2. **RIGIDITY** — the mass being proportioned in the most scientific manner.
3. **QUALITY OF MATERIAL** — only the best quality of kiln-dried lumber used.
4. **QUALITY OF WORKMANSHIP** — only most skilled cabinetmakers employed.
5. **FINISH** — durable and handsome in appearance.
6. **UTILITY** — dimensions are right for character of use, cupboard and drawer space are commodious and conveniently placed.

STANDARD PHYSICS TABLE



No. 1–100

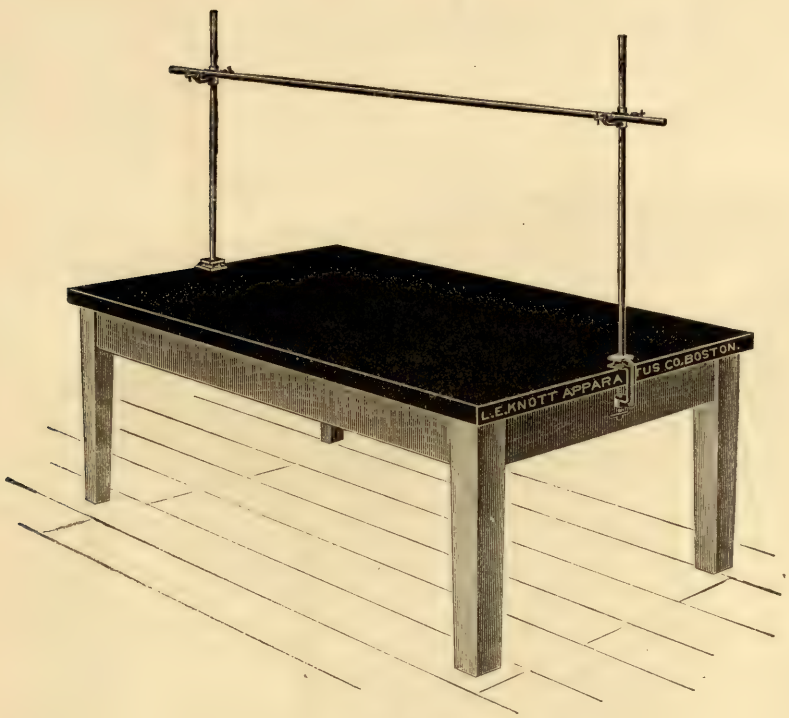
1–100 **PHYSICS TABLE** with **FIXED UPRIGHT** and **ADJUSTABLE CROSS-BAR.** This table has been so universally used for the last fifteen years that it is considered the Standard Physics Laboratory Table. The body is made of selected kiln-dried ash, oil and wax finish, presenting a handsome finish, accentuating the grain of the wood. The top is built up of best, straight-grained, kiln-dried strips, matched in such a manner as to prevent warping, and then glued. It is finished a durable black acid-proof finish. Uprights and cross-bar are of ash, 1½ inches by 3 inches, finished to match body, cross-bar being held by the Knott Special Three-Part Clamp which readily allows adjustment without binding and which will fix the bar firmly where desired.

The table is 6 feet long, 4 feet wide, standing height of 34 inches. It is equipped with four drawers, two on each side.

Each, f.o.b. Factory, **$25.50**

We are prepared to furnish tables of any desired finish to match furniture already in the building, and, if the order is sufficiently large, this can be done without extra charge.

PHYSICS TABLE



No. 1–120

1–120 PHYSICS TABLE. This table has found considerable favor in Physics Laboratories from the fact that, for the uprights and cross-bar, the rods and clamps with which laboratories are so universally equipped may be utilized. The detachable feature, leaving clear the whole top of the table, is a distinct advantage.

This table is of same high quality as No. **1–100.** It is six feet long, four feet wide, thirty-four inches high. It is not provided with drawers, as in laboratories provided with ample storage facilities, they may be considered unessential.

With each table are furnished accessories for uprights and cross-bar attachments as follows:

Two **5–1150** "Harcourt" Universal Basic Clamps "B."
Two **5–20e** Threaded Rods, 19 millimeters diameter, for uprights.
Two **5–765** Right Angle V Clamps.
One **5–40c** Support Rod for Cross-Bar 19 millimeters diameter.

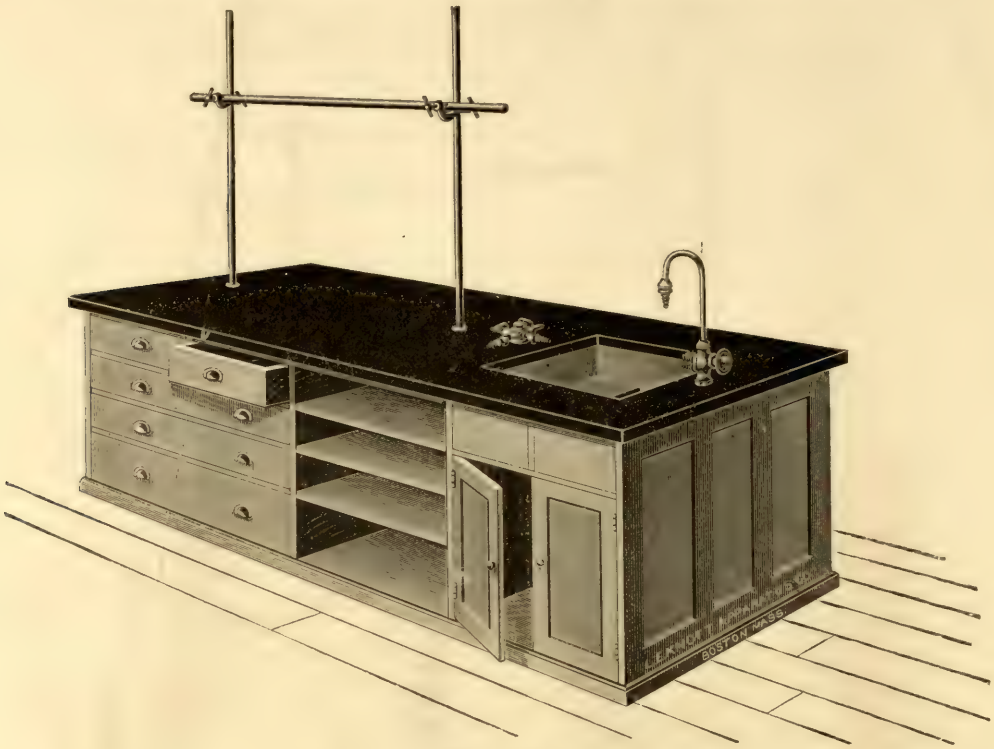
Table complete as above, f.o.b. Factory, **$27.25**

1–125 PHYSICS TABLE. This table is the same table as No. **1–120,** but is furnished without accessory attachments for uprights and cross-bar, as they are not required where a laboratory already has such an equipment.

Table only, f.o.b. Factory, **$22.50**

We are prepared to furnish tables of any desired finish to match furniture already in the building, and, if the order is sufficiently large, this can be done without extra charge.

STANDARD LECTURE TABLE



No. 1–150

1–150 COMBINATION LECTURE TABLE, for either **PHYSICS** or **CHEMISTRY LECTURE ROOM.** This table has the distinctive qualities of all our laboratory furniture. The body is made of selected kiln-dried ash, oil and wax finish. Top is built up from narrow, straight-gained, selected, kiln-dried strips, matched in such a manner as to prevent warping and then glued. It has a durable black acid-proof finish.

It is furnished equipped with plumbing to the floor line for both gas and water and supplied with the Knott Special Goose-neck Water Faucet which carries three attachments, — one for small rubber hose, one for large, and one for attachment with an aspirator. It has, in addition, one four-way Knott Turrett for gas supply and a Special Gas Cock with lever handle and long serrated ends.

It is equipped, also, with two No. **5–274** nickel-plated Flush Sockets, two No. **5–20e** Support Rods, two No. **5–765** Right Angle Clamps and No. **5–40b** Support Rod for Cross Bar.

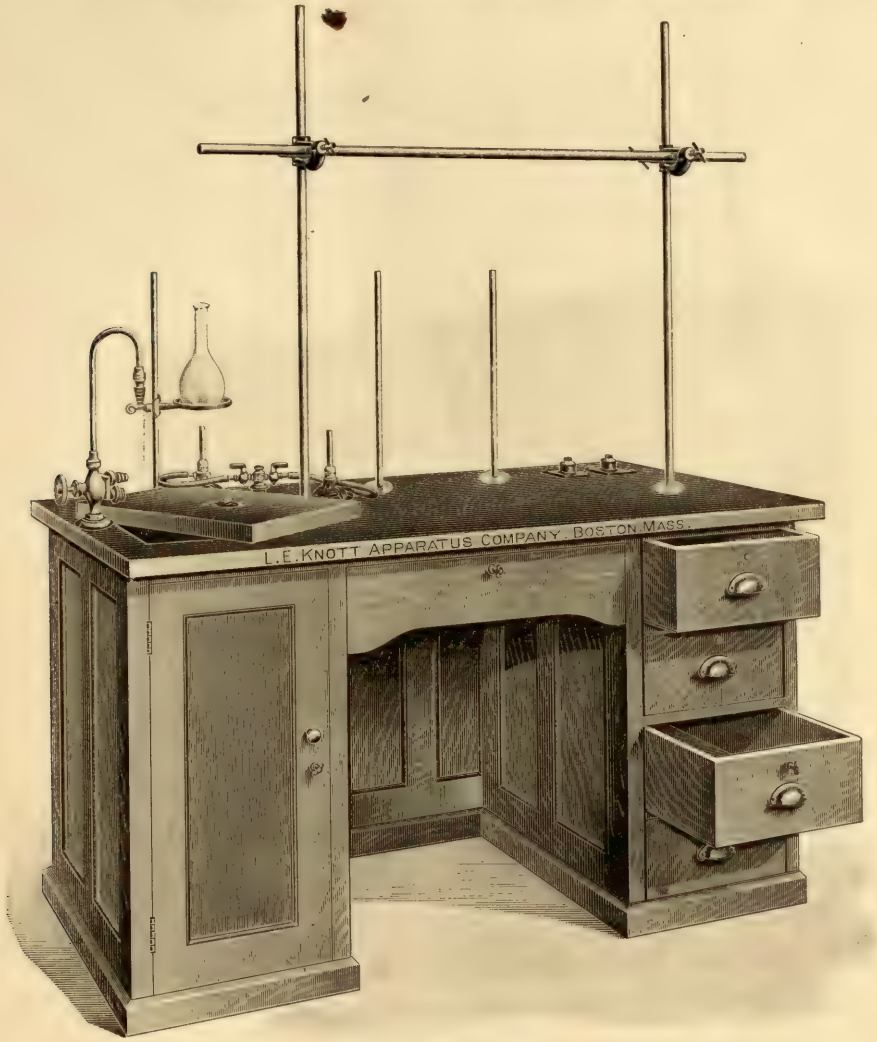
The design of this desk is such as to afford best facilities for Lecture Table Storage and Lecture Table Demonstration. Top is supplied with heavy lead-lined water-tight pneumatic sink, 18 inches square by 16 inches deep, with a shelf 8 inches wide placed 6 inches from the top. The front and ends are paneled and back is equipped with three large and two small drawers, four open shelves and commodious cupboard.

This table is carried in stock 8 feet long by 3 feet wide, with the standing height of 34 inches.

Each, f.o.b. Factory, **$98.00**

We are prepared to furnish tables of any desired finish to match furniture already in the building, and, if the order is sufficiently large, this can be done without extra charge.

INSTRUCTOR'S TABLE



No. 1–200

1–200 INSTRUCTOR'S LABORATORY TABLE for small lecture room. The body of this table is of ash, oil and wax finish. The top is built up from straight-grained, kiln-dried strips with special black acid-proof finish.

It is furnished equipped with plumbing to the floor line for gas and water and supplied with the Knott Special Goose-neck Faucet which carries three attachments, — one for small and one for large rubber tubing connections, and one for attachment of aspirator, a Two-Way Turret for gas connections and a Special Lever-Handle Gas Cock with long serrated ends. Set into the top of the table is a heavy, lead-lined, water-tight sink, $16 \times 10 \times 9$ inches deep.

The top is further equipped with three No. **5–270** and two No. **5–274** Flush Plates for the three No. **5–10e** and two No. **5–20e** Support Rods, one No. **5–40a** Support Rod for Cross-Bar and two No. **5–765** Right Angle V Clamps. Electrical Connections illustrated are furnished only on application and at an extra charge.

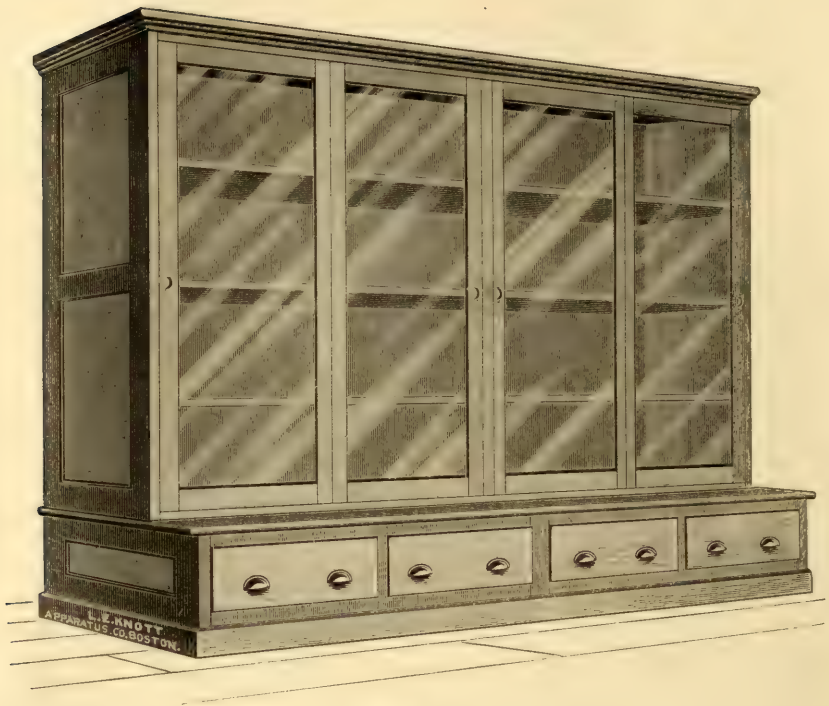
This table is designed to obtain the greatest utility in smallest space. The front and ends are paneled; the back has five drawers and commodious cupboard space.

The table is 5 feet long by $2\frac{1}{2}$ feet wide by 34 inches high.

Each, f.o.b. Factory, **$62.00**

We are prepared to furnish tables of any desired finish to match furniture already in the building, and, if the order is sufficiently large, this can be done without extra charge.

APPARATUS CABINET



No. 1-250

1-250 APPARATUS CABINET for the storage and display of Physical and Chemical Apparatus. Substantially constructed of ash, oil and wax finish, panel ends, front roller doors accurately fitted, dustproof and run on steel tracks, each door fitted with handle, lock and key. Furnished with three adjustable shelves and four large drawers.

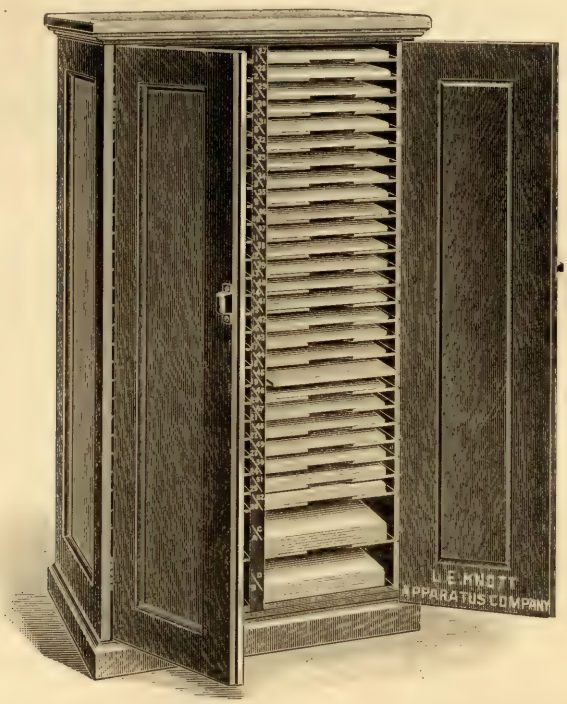
This cabinet is 9 feet wide; upper part measures 5 feet, 2 inches; lower part 15 inches high; height over all 6 feet, 5 inches. Drawers measure $24\frac{1}{2} \times 25 \times 11$ inches deep.

Cabinet complete as illustrated, with three shelves.

Each, f.o.b. Factory, **$95.00**

We are prepared to furnish cabinets of any desired finish to match furniture already in the building, and, if the order is sufficiently large, this can be done without extra charge.

LOOSE-LEAF FILING CABINET



No. 1–650

1–650 LOOSE-LEAF CABINET for storage and filing of loose-leaf material of all kinds.

This cabinet, originally designed to fulfil the demand for storage and filing facilities for Loose-Leaf Note-Book material, has found a place of equal value in the offices of school superintendents and principals. Its adaptability to the filing of school records for instant reference, is unsurpassed by any system of filing. By opening the two doors, the entire fifty-six compartments, all legibly numbered, become at once available. Each compartment has a capacity of from 150 to 200 separate sheets of paper, with four wide compartments at the bottom, each capable of holding 1,000 or more sheets.

The convenience of this cabinet in the storing of Direction Sheets of Loose-Leaf Note-Books is at once apparent, as noted in our illustration, and Educational Institutions using a Loose-Leaf System of Instruction will readily realize the necessity of ample storage, indexed for instant reference.

The cabinet is substantially built of ash with paneled sides and doors, heavy moulding at top and bottom. It is carried in stock attractively finished in antique oak.

Dimensions over all, — height 40 inches, width 21½ inches, depth 13½ inches.

Each, f.o.b. Factory, **$18.00**

We are prepared to furnish cabinets of any desired finish to match furniture already in the building, and, if the order is sufficiently large, this can be done without extra charge.

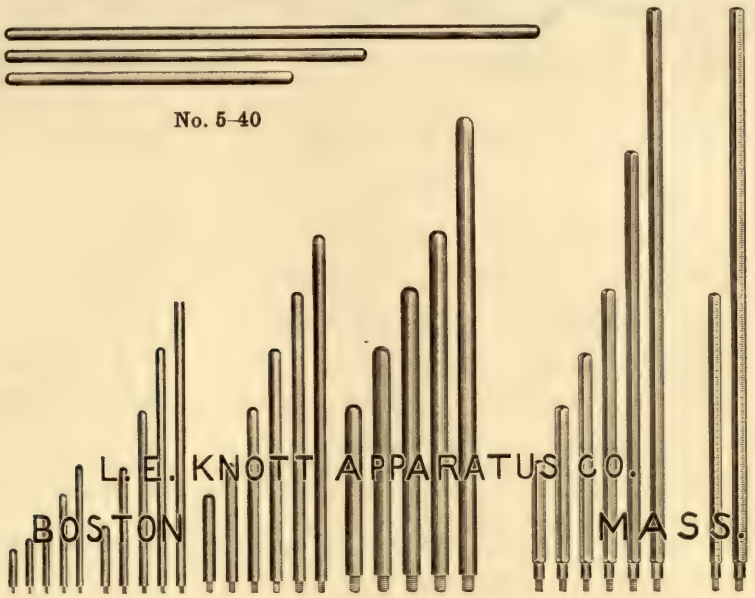
INTERCHANGEABLE LABORATORY SUPPORTS

THE following accessories for laboratory use are particularly adapted to requirements of rigidity. The accuracy possible with their use fully warrants the initial expense. Designed primarily for use on the lecture table, their effectiveness as scientific supports has made them highly desired in any well-equipped laboratory. Their adaptability to all classes of work, their interchangeability and general utility appeal to all.

The original idea of these supports was suggested by Prof. S. W. Stratton, Director of the National Bureau of Standards. Since this initial introduction there have been a number of improvements and additions. We have tried to adapt our designs in such a manner as to secure all of the best features. We wish to state that in formulating our designs, we have not been unduly influenced by competitive prices, and for this reason, having unbiased ideas, it will be found that our designs have features which, though impossible of illustration or adequate description will recommend themselves to all who have used or desire to equip in this line. Designs originating with us have suggested themselves naturally as their extreme utility has been demonstrated in our laboratory. They fill not only special requirements but afford a latitude never heretofore attained.

SUPPORT RODS

Our Rods are of Bessemer Steel, copper-plated and heavily nickeled, thus obviating the possibility of rust deterioration. They are straight, of uniform diameter, machine threaded, and shoulders faced to attain a perfect junction when used on our tripod bases.



No. 5–40

Nos. 5–10 to 5–55

5–10 SUPPORT RODS, 10 millimeter diameter, threaded to fit any hole tapped ¼ × 20.

	a	b	c	d	e	
Length	10	15	20	30	40	centimeters.
Each	**$0.16**	**.18**	**.20**	**.25**	**.29**	

5–15 SUPPORT RODS, 13 millimeter diameter, threaded to fit any hole tapped ⅜ × 16.

	a	b	c	d	e	
Length	20	40	60	80	100	centimeters.
Each	**$0.25**	**.35**	**.44**	**.55**	**.68**	

5–20 SUPPORT RODS, 19 millimeter diameter, threaded to fit any hole tapped ½ × 12.

	a	b	c	d	e	f	
Length	30	40	60	80	100	120	centimeters.
Each	**$0.42**	**.52**	**.70**	**.88**	**1.00**	**1.15**	

5–30 SUPPORT RODS, 30 millimeter diameter, threaded to fit any hole tapped ¾ × 10.

	a	b	c	d	e	
Length	60	80	100	120	160	centimeters.
Each	**$1.42**	**1.70**	**1.95**	**2.25**	**2.70**	

5–40 SUPPORT RODS, for use as horizontal rods, 19 millimeter diameter, ends rounded.

	a	b	c	
Length	100	125	185	centimeters
Each	**$0.90**	**1.05**	**1.95**	

5–50 SQUARE SUPPORT RODS, 19 millimeters square, one end turned to 19 millimeter diameter, and threaded to fit any hole tapped ½ × 12. No. **5–50 d–f** are most frequently used as bed-rods of optical benches.

	a	b	c	d	e	f	
Length	40	60	80	100	120	200	centimeters.
Each	**$1.32**	**1.55**	**1.95**	**2.15**	**3.10**	**4.35**	

5–55 SQUARE SUPPORT RODS, same as Nos. **5–50d** and **5–50f**, but graduated to millimeters. A few of these rods are valuable additions to every laboratory, as they may be used in many ways besides as bed-rods for optical benches, — the purpose for which they were originally intended.

	a	b	
Length	100	200	centimeters.
Each	**$6.50**	**10.75**	

MISCELLANEOUS BASES

Nos. 5–100 to 5–215

TRIPOD BASES

Our tripods are designed to present a rigid base for all work. The legs of these bases are made to cover a circle somewhat in excess of the tripods on the market and having proportioned our designs so that the center of mass is low and excess of weight away from center as far as practicable we secure ample stability. Each tripod is faced top and bottom that shoulders of Support Rods may make close junction and may be in true perpendicular with the plane of the base. All holes are machine drilled and threaded.

Our castings are uniformly smooth, thus offering a good surface for a strikingly smooth and beautiful finish. All sizes are carried in stock with and without leveling screws.

5–100	**TRIPOD BASE,** with leveling screw, length of leg 6 centimeters, tapped ¼ × 20 to take any 10 millimeter rod	$0.84
5–101	" " Same as above, without leveling screws	.26
5–104	**TRIPOD BASE,** with leveling screw, length of leg 8 centimeters, tapped ¼ × 20 to take any 10 millimeter rod	.98
5–105	" " Same as above, without leveling screws	.28
5–110	**TRIPOD BASE,** with leveling screws, length of leg 10 centimeters, tapped ¼ × 20 to take any 10 millimeter rod	1.10
5–111	" " Same as above, without leveling screws	.34
5–114	**TRIPOD BASE,** with leveling screws, length of leg 12 centimeters, tapped ¼ × 20 to take any 10 millimeter rod	1.20
5–115	" " Same as above, without leveling screws	.44
5–120	**TRIPOD BASE,** with leveling screws, length of leg 14 centimeters, tapped ⅜ × 16 to take any 13 millimeter rod	1.35
5–125	" " Same as above, without leveling screws	.52
5–130	**TRIPOD BASE,** with leveling screws, length of leg 18 centimeters, tapped ⅜ × 16 to take any 13 millimeter rod	1.85
5–135	" " Same as above, without leveling screws	.68
5–140	**TRIPOD BASE,** with leveling screws, length of leg 18 centimeters, tapped ½ × 12 to take any 19 millimeter rod	1.85
5–145	" " Same as above, without leveling screws	.68
5–150	**TRIPOD BASE,** with leveling screws, length of leg 21 centimeters, tapped ½ × 12 to take any 19 millimeter rod	2.15
5–155	" " Same as above, without leveling screws	.94
5–160	**TRIPOD BASE,** with leveling screws, length of leg 26 centimeters, tapped ½ × 12 to take any 19 millimeter rod	3.15
5–165	" " Same as above, without leveling screws	1.55
5–170	**TRIPOD BASE,** with leveling screws, length of leg 26 centimeters, tapped ¾ × 10 to take any 30 millimeter rod	3.15
5–175	" " Same as above, without leveling screws	1.55
5–180	**TRIPOD BASE,** with leveling screws, length of leg 50 centimeters, tapped ¾ × 10 to take any 30 millimeter rod	6.90
5–185	" " Same as above, without leveling screws	4.80

ROUND BASES

In the design of our Round Bases we have followed the same rules for stability as in our Tripod Bases. Our Castings are uniformly smooth, bases faced top and bottom, machine drilled and tapped, handsomely finished.

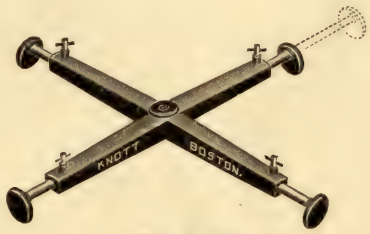
5–200	**ROUND BASE,** diameter 8 centimeters, tapped ¼ × 20 to take any 10 millimeter rod	$0.20
5–205	**ROUND BASE,** diameter 10 centimeters, tapped ¼ × 20 to take any 10 millimeter rod	.22
5–210	**ROUND BASE,** diameter 12 centimeters, tapped ⅜ × 16 to take any 13 millimeter rod	.32
5–215	**ROUND BASE,** diameter 15 centimeters, tapped ⅜ × 16 to take any 13 millimeter rod	.50

"THE KNOTT" ADJUSTABLE ECCENTRIC LEVELING BASES

The design illustrated has been the outgrowth of the demand for a base that will give a greater stability than a Tripod Base and whose figure of stability will approach that of a Round Base. The design which we have originated meets these requirements and in addition the figure of stability may be readily varied to meet the individual requirements of the apparatus supported, at the same time offering ready means of rapid leveling by means of the eccentrically mounted disc feet at ends of the adjustable legs.

We manufacture two sizes. With our smaller size we secure a figure of stability equivalent to that of any Round Base from 11¼ to 18¼ inches in diameter; with the larger, from 18½ to 32 inches in diameter, obviating in each size the objectionable weight of Round Bases of equal stability.

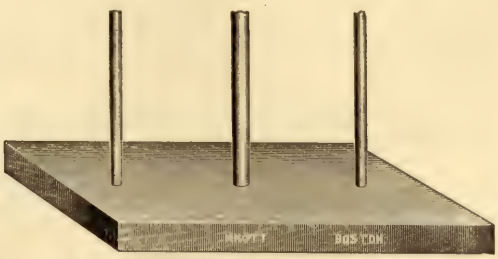
No. 5–250
Patent Pending



No. 5–252
Patent Pending

5–250 **"THE KNOTT" ADJUSTABLE ECCENTRIC-LEVELING BASE,** adjustable to cover an area from 11¼ to 18¼ inches in diameter **$2.35**

5–252 **"THE KNOTT" ADJUSTABLE ECCENTRIC-LEVELING BASE,** adjustable to cover an area from 18½ to 32 inches in diameter **3.65**



No. 5–260

5–260 **PLATE-BASE,** as used by C. H. Andrews, South High School, Worcester, Mass. Consists of heavy plate casting 18 × 10 × 1¼ inches, tapped near ends ½ × 12 to hold 19 millimeter rods, and center ⅜ × 16 to hold 13-millimeter rod. Uniform casting, neatly finished.

Advantages of this plate are extreme rigidity due to massive structure, mobility to any part of table, and capability of use of three rods on same base **$4.90**

Nos. 5–270 to 5–274

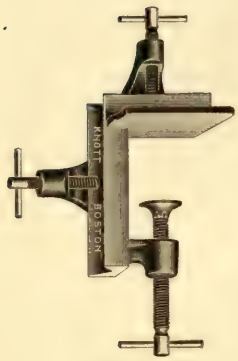
FLUSH PLATES, for fitting to any laboratory table flush with the top. These plates are made of brass, polished, and heavily nickel plated. When fitted to a table and screwed into place, they offer a support amply rigid for ordinary laboratory operations.

5–270 **FLUSH PLATE,** tapped ¼ × 20 to take any 10-millimeter rod **$0.35**

5–272 **FLUSH PLATE,** tapped ⅜ × 16 to take any 13-millimeter rod . . . . . **.45**

5–274 **FLUSH PLATE,** tapped ½ × 12 to take any 19-millimeter rod . . . . . **.70**

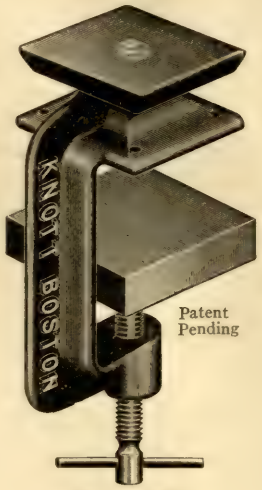
MISCELLANEOUS SUPPORTS



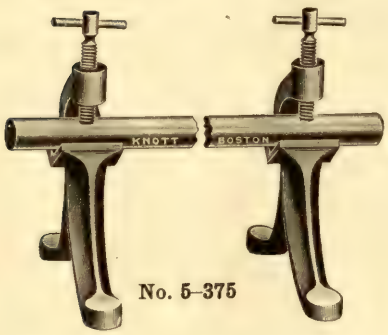
No. 5–350

5–350 TABLE CLAMP, for attaching to edge of table to hold round or square rods in either horizontal or vertical position. V's and extra broad flange are carefully milled. To be used on table 7.5 centimeters or less thick **$1.45**

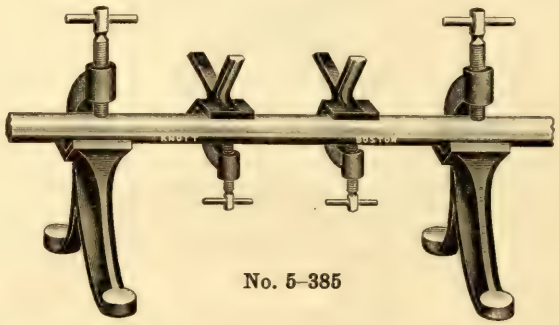
5–360 TABLE CLAMP, for attaching to edge of table to hold round or square rods in vertical position. This design obviates danger of injury to table, yet at same time, from its structure, offering a rigid support. Tapped ½×12 to take 19-millimeter rod **1.90**



No. 5–360



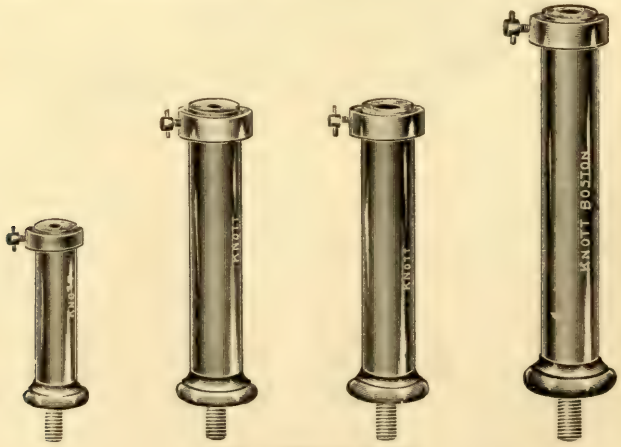
No. 5–375



No. 5–385

5–375 END SUPPORTS for supporting rods in a horizontal position, originally designed for holding bed-rod of optical benches. Extreme care is exercised in machining these supports so that they will satisfy all requirements . . . . . Per Pair **$1.00**

5–385 SECONDARY SUPPORTS for attaching to round or square rods to support objects in horizontal position. Convenient for holding telescopes; also for levels in level-testing experiments . Per Pair **1.10**



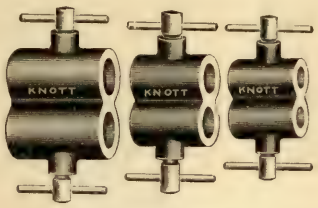
Nos. 5–400 to 5–415

5–400 STAND TUBE, into which a 13-millimeter rod may be telescoped and clamped at desired heights within range of 20 centimeters, — the height of the tube. In conjunction with a base tapped ⅜ × 16 and with **STAND TOPS** Nos. **5–475** and **5–480,** will make an adjustable table support **$1.10**

5–405 ——, same as above, but 30 centimeters long **1.35**

5–410 STAND TUBE, for use as in No. **5–400,** to take 19-millimeter rod, and will fit any base tapped ½ × 12. Length 30 centimeters. Will require No. **5–485** or **5–490** **1.85**

5–415 ——, same as above, but 40 centimeters long **2.20**



Nos. 5–430 to 5–440

No. 5–450

5–430 **EXTENSION CLAMP,** for holding two rods adjustably parallel to each other. For two 19 millimeter rods $0.66

5–435 ——, same as above, but for two 13 millimeter rods 54

5–440 ——, same as above, but for two 10 millimeter rods 48

5–450 **EXTENSION CLAMP** for holding two rods adjustably parallel to each other. This clamp has been designed to obviate the inconveniences of the old form with parallel holes which must be attached to the rod by placing it over the ends. Our new design for use with 10 to 19 millimeter rods may be slipped on the rod and clamped by the nickel-plated T screw 65

Nos. 5–470 to 5–490

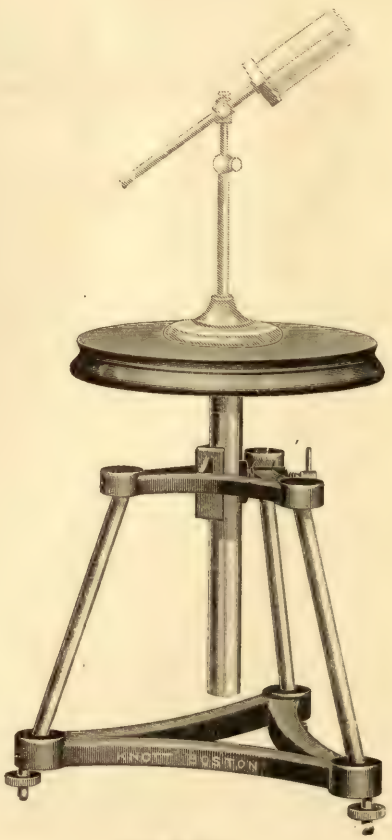
5–470 **STAND TOP,** 15 centimeters diameter, tapped for use with any 10 millimeter rod threaded $\frac{1}{4} \times 20$. Frequently used in conjunction with Stand Tube No. **5–400** or **5–405,** and a suitable base to form an adjustable table. Made of three-ply wood to prevent warping $0.92

5–475 **STAND TOP,** 15 centimeters in diameter, but tapped to receive any 13 millimeter rod threaded $\frac{3}{8} \times 16$ 92

5–480 ——, same as above, but 20 centimeters in diameter 1.40

5–485 **STAND TOP,** 20 centimeters in diameter, but tapped to receive any 19 millimeter rod threaded $\frac{1}{2} \times 12$ 1.48

5–490—, same as above, but 30 centimeters in diameter . 1.80

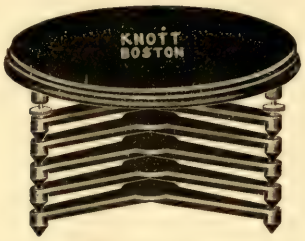


No. 5–510

5–510 **ADJUSTABLE LABORATORY STAND** for table use. This stand is substantially built of metal, with three-ply wood top. This top is adjustable in height from the minimum height of 40 centimeters to a maximum of 70 centimeters.

This stand will be found of great convenience on the lecture table. The stand being heavy and the center of gravity low, the top may be clamped as any table top and a system of rods and clamps utilized to gain greater latitude and adjustment $9.50

5–511 **ADJUSTABLE LABORATORY STAND,** same as above, top adjustable from 70 to 130 centimeters . 15.00



No. 5–515

No. 5–515a No. 5–515b

5–515 GEOMETRIC STANDS, for blocking up apparatus. Set consists of six tripods fitting into each other, the uppermost surmounted by neat wooden top 13 inches in diameter. Top alone with its leveling screws gives an adjustment from 2⅜ inches, the minimum height, to 3 inches, the maximum. Each tripod varies height by 1⅛ inches. Total maximum height 8½ inches Per Set of Six **$4.15**

5–515a TRIPOD WITH WOOD TOP, and leveling screws as used in above . . . . . Each **1.75**

5–515b TRIPOD only, as used in above . . . . . Each **.50**

Nos. 5–525 to 5–545

5–525 PLATFORM for 10 millimeter rod. Made of cast iron, top carefully milled true. Top 7 × 8.5 centimeters **$0.60**

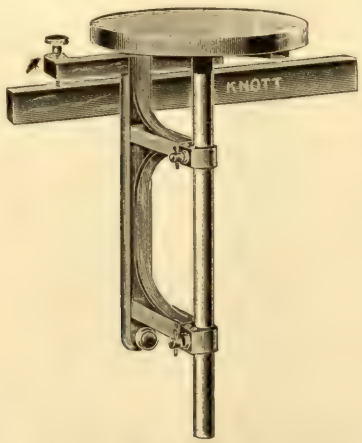
5–527 ——, same as above, for 19 millimeter rod . . . . . **.60**

5–530 ——, same as above, for 10 millimeter rod, top 8.5 × 11.5 centimeters . . . . . **.75**

5–535 ——, same as above, for 13 millimeter rod, top 8.5 × 11.5 centimeters . . . . . **.75**

5–540 ——, same as above, for 13 millimeter rod, top 11.5 × 15.5 centimeters . . . . . **.94**

5–545 ——, same as above, for 19 millimeter rod, top 14.5 × 21.5 centimeters **1.35**



No. 5–570

5–570 WALL STAND, of general utility in laboratory practice. Designed to be placed on a rail fixed to the wall or laboratory table. Wood plate, 30 centimeters in diameter, oil and wax finish, mounted adjustably on 19 millimeter rod **$12.50**

No. 5–590

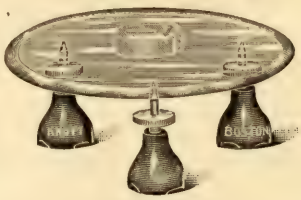
No. 5–595
Patent Pending

5–590 **KNIFE EDGE BRACKET** for attachment to the side of a room as a knife edge support for a rod in Bending Beam experiments.
This bracket is made of cast iron from a pattern of our own design. It is handsomely japanned and the knife edge carefully milled true . . . . . Each **$0.90**

5–595 **KNIFE EDGE CLAMP** for attaching to the edge of a table top to form an adjustable support for a beam in Bending Beam experiments.
This clamp is one of our T-Beam Series (see No. **5–1060**) and highly recommended for the universal adaptation which is one of its unique features.
Clamp complete as illustrated **1.80**

5–597 **KNIFE EDGE CLAMP ATTACHMENT ONLY.** (Same as No. **5–1060**) . . . . . **.65**

5–598 **" HARCOURT " UNIVERSAL T-BEAM BASIC CLAMP " A."** (Same as No. **5–1000**) **1.15**



No. 5–610

5–610 **LEVELING SCREWS,** for use in sets of three for rapidly leveling a plane surface. Made entirely of metal, base accurately milled. Adjustable from minimum height of 65 millimeters to 90 millimeters.
Per set of three **$1.95**

Nos. 5–635 to 5–638

Nos. 5–645 to 5–646

5–635 **COLLAR** for allowing a clamped rod to freely revolve and yet keeping rod at height fixed by position of collar. Designed for 30 millimeter rod **$0.75**

5–636 ——, same as above but for 19 millimeter rod . . . . . **.60**

5–637 ——, same as above but for 13 millimeter rod . . . . . **.48**

5–638 ——, same as above but for 10 millimeter rod . . . . . **.36**

5–645 **HOOK COLLAR** for 10 millimeter rod. The addition of a hook to a collar has been found exceedingly useful in our laboratory work. Its use as a support may be noted in illustration of Nos. **27–290** and **27–300.** It may readily be adapted to a multitude of uses when a system of Interchangeable Laboratory Supports is a part of the school equipment . . . . . Each **.22**

5–646 **HOOK COLLAR,** same as above but for 13 millimeter rod . . . . . Each **.24**

No. 5–670

5–670 **RIGHT ANGLE PIECE** for clamping two 10 millimeter rods at right angles to each other. Neatly nickel plated with two nickel plated T-screws **$0.50**

CLAMPS

Our **Clamps** are unique in that they are designed to give maximum strength at stress points with use of as little metal as practical to preserve symmetry. All our clamps are ribbed at points of stress; our castings are uniform and smooth, thus presenting a good surface for a smooth, handsome, and durable finish; all parts at right angles or parallel are as accurate as machinists' skill can produce. As jigs and standard gauges are used as far as practicable, each lot will be found uniform in dimensions. All holes are reamed to a sliding fit; all screws are heavily nickel plated and of size proportional to size of clamp; all V's are accurately milled.

No. 5–730

No. 5–745

No. 5–760

No. 5–765

No. 5–770

No. 5–785

No. 5–810

No. 5–825

5–725 **RIGHT ANGLE CLAMP,** for holding two rods in planes accurately at right angles to each other. V opening to clamp 13 millimeter rod, hole for 10 millimeter rod **$0.45**

5–730 ——, same as above, but V opening to clamp 19 millimeter rod, hole for 13 millimeter rod . . . . . **.65**

5–735 **RIGHT ANGLE CLAMP,** for use in holding optical bench accessories. V opening to clamp 19 millimeter rod, hole for 13 millimeter rod. Central (zero) point indicated . . . . . **.90**

5–740 **RIGHT ANGLE CLAMP,** for use in holding optical bench accessories. V opening to clamp 19 millimeter rod, hole for 10 millimeter rod. Central (zero) point indicated . . . . . **.60**

5–745 **RIGHT ANGLE CLAMP,** V opening to clamp 30 millimeter rod, hole 19 millimeters . . . . . **.90**

5–760 **RIGHT ANGLE CLAMP,** for holding two rods in planes accurately at right angles to each other. Two V openings for clamping 13 millimeter rods . . . . . **.70**

5–765 ——, same as above, but with two V openings for clamping 19 millimeter rods . . . . . **.80**

5–770 **"HARCOURT" RIGHT ANGLE CLAMP,** for holding two rods in same plane at right angles to each other. Two V openings for clamping 13 to 19 millimeter rods, one accurately perpendicular to the other.
This form of clamp will be found a marked improvement over types on the market, as more rapid changes and adjustments are possible. Its universal adaptability in places not possible with old forms will readily be noted . . . . . **.95**

5–785 **RIGHT ANGLE CLAMP,** for holding two rods in same plane but accurately at right angles to each other. V opening to clamp 19 millimeter rod, tapped $\frac{1}{4} \times 20$ to receive 10 millimeter rod . . . . **.42**

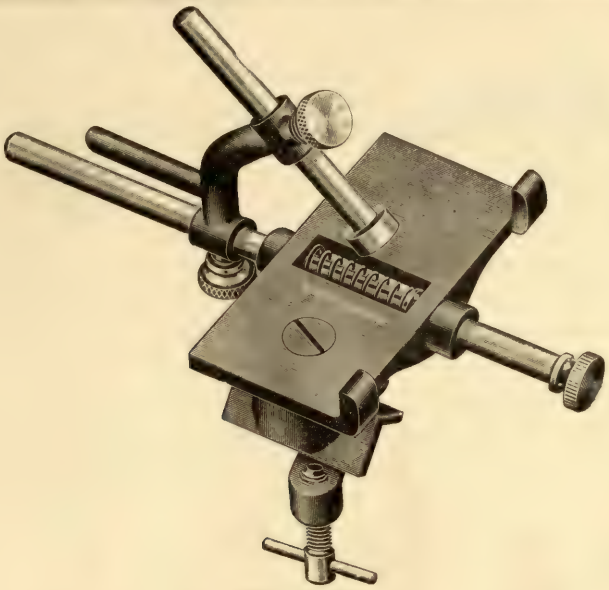
5–790 ——, same as above, but tapped $\frac{3}{8} \times 16$ to receive 13 millimeter rod . . . . . **.55**

5–810 **RIGHT ANGLE CLAMP,** for holding two rods in same plane but at right angles to each other. V opening to clamp to 19 millimeter rod, hole 10 millimeters. Convenient for holding accessories having shank 10 millimeters in diameter . . . . . **.85**

5–815 **RIGHT ANGLE CLAMP,** convenient for use on Optical Bench, assembled from "Interchangeable Laboratory Supports" as central (zero) point is indicated. V opening to clamp to 19 millimeter rod, hole for 10 millimeter rods . . . . . **.95**

5–820 ——, same as above, but V opening to clamp 19 millimeter rod, hole 13 millimeters . . . . . **.85**

5–825 **RIGHT ANGLE CLAMP WITH SLIDING SPRING CONTACT.** Same as No. **5–815** but with addition of device which holds clamp firmly to the bed-rod yet at same time allowing of firm sliding motion along the rod. This clamp is advised for use as support for Photometer Boxes as it allows of motion along rod without unlocking the set screw . . . . . Each **1.70**



No. 5–840
Patent Pending

5–840 SWIVEL-CLAMP UNIVERSAL HOLDER, for holding in any position flat or round measures, thermometers, burettes, tubes, screens, telescopes, telescope scales, and, in fact, any object flat or cylindrical which is not over 50 millimeters in diameter nor over 155 millimeters wide and 30 millimeters thick.

This device consists essentially of two parts, — a holder and a swivel-clamp, the holder attached to the swivel-clamp in an ingenious manner by which it may be firmly set in position by a T screw, and yet without removing from the rod, capable of universal motion in one plane by simply diminishing the pressure of the screw against the rod. This swivel-clamp will be found a prominent feature in the use of this holder.

The holder is designed especially to meet the requirements of its manifold uses. The essential part is a broad plate. At the edge of this broad plate are two projections against which the object to be held is laid. A plunger rod carries an arm which is adjustable along the rod and it in turn carries an adjustable contact rod tipped with cork. In use the object is placed against the projections at the edge of the broad plate. Knob at end of plunger rod is pushed in, thus acting against a compression spring. The arm carrying the contact rod is adjusted on the plunger rod and the position of the contact rod on this arm is adjusted so that when pressure of thumb is removed from compression spring the object is firmly clamped by force of the spring. (See Figure **1**.) The projection to the rear of the arm is a straight rod to be used with arm reversed on plunger rod when a flat object is to be clamped. (See Figures **2** and **3**.)

This Universal Holder will be found a valuable addition to any laboratory. Its use is unlimited; positions possible are multitudinous; facility, convenience, and rapidity of changes are unexcelled. As it will hold a great range of sizes from small to large, adapting itself instantly to these changes, and support objects in any position it might well be called a system of clamps combined in one.

It is handsomely finished in bright japan and nickel-plate. All parts are carefully fitted and substantial in structure **$4.50**

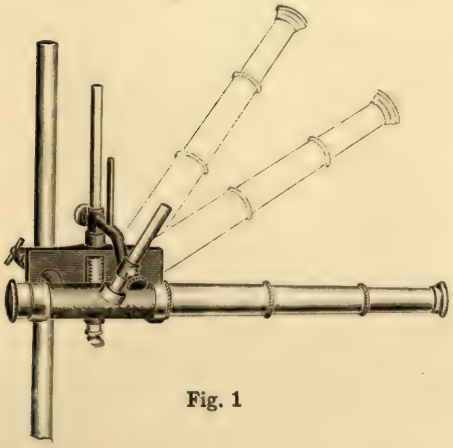


Fig. 1

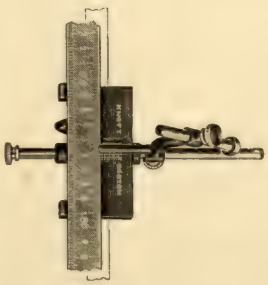


Fig. 2

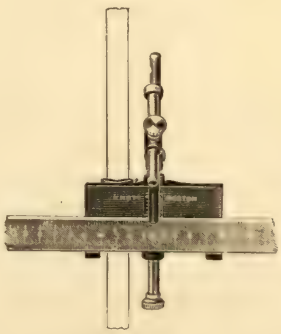
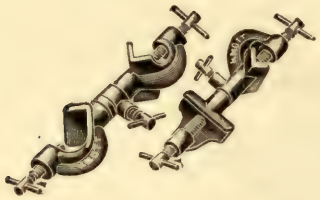
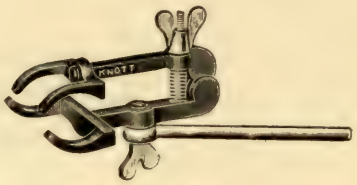


Fig. 3



Nos. 5–850 and 5–855

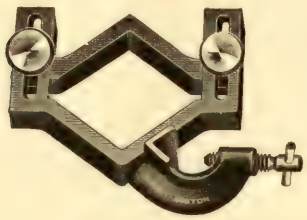


No. 5–875

5–850 **UNIVERSAL RIGHT ANGLE CLAMP,** for holding two rods in various planes at right angles to each other. Provided with swivel for locking. Two V openings to clamp 19 millimeter rods . . . **$1.05**

5–855 ——, same as above, but with two V openings for clamping 13 millimeter rods . . . . . **.90**

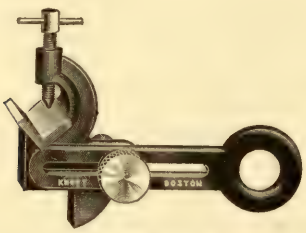
5–875 **UNIVERSAL CLAMP,** for large objects up to 8 centimeters in diameter, regular or irregular in shape. Position adjustable by swivel through 180 degrees. Finished in japan and nickel plate **1.75**



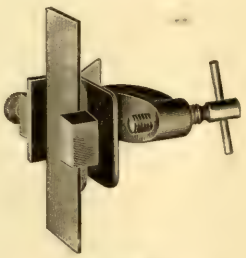
No. 5–887

No. 5–891

No. 5–885



No. 5–889



No. 5–895

5–885 **BOTTLE CLAMP,** for clamping a bottle by its neck and supporting same to an upright. V clamp for 13 millimeter rod. Will clamp firmly any diameter from 25 millimeters to 30 millimeters. In use see No. **53–200** **$0.85**

5–887 **ADJUSTABLE TUBE CLAMP,** for supporting a tube in an upright or horizontal position. This is a two-part casting, one part designed with a V clamp for attaching to a 13 millimeter rod, the second part held adjustably to the first by two thumb screws, thus accommodating a tube from 1¼ inches (32 millimeters) to 1¾ inches (45 millimeters) in diameter. In use see No. **53–200** . . **.95**

5–889 **ADJUSTABLE ARM SUPPORT WITH CLAMP.** This is a two-part casting, one provided with a V for clamping to a 13 millimeter rod, the other with countersunk hole at the end of a slotted arm. This arm is adjustable to the length of the slot and may be clamped in any position by means of a thumb screw. In use see No. **53–200** . . . . . **.85**

5–891 **ROD V CLAMP,** for use with any V clamp in securing a greater latitude of adjustment. V opening to take 10 or 13 millimeter rod. Rod 13 millimeter diameter, 11 centimeters long. . . . . **.55**

5–895 **METER STICK CLAMP,** V opening for clamping to a 13 or 19 millimeter rod, face plate and adjustable locking device for holding the standard meter stick. Surfaces of V and of face plate carefully milled parallel . . . . . **.55**

No. 5–900

5–900 **PENDULUM CLAMP,** for adjustably supporting four pendulums. This clamp, similar in design to the one on the market is improved so that it may carry four pendulums, thus making possible a direct comparison of pendulum lengths of periods as 1: 2: 3: 4. The clamp itself is of a smooth, uniform casting, carrying four removable clamps designed to give exact points of suspension for accurate measurement of lengths. This clamp consists of a flat brass piece with guide pin held to the main clamp by a polished and lacquered thumb screw. The guide pin secures a position which will always bring the brass piece flush with the lower edge of the clamp proper, thus fixing the exact point of suspension **$1.45**

5–902 **PENDULUM CLAMP,** similar to above but usual form designed to hold three pendulums **1.05**

For **Complete Pendulum Apparatus** see Section **25.**

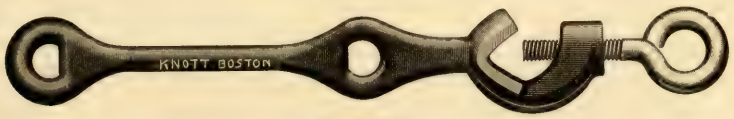
No. 5–905

5–905 **PENDULUM CLAMP** for holding four pendulums in bi-filar suspensions.

This clamp obviates the inconveniences of the ordinary type in that it gives a directive force to the swinging pendulums. It is especially adapted for four pendulums of different vibration periods.

It consists of a smooth uniform casting in which are placed taper plugs, two for each pendulum ball. These tapered plugs are carefully fitted to their respective holes and the lengths of the suspending chords are readily adjusted and held by the friction of the tapers against the sides of the holes **$2.90**

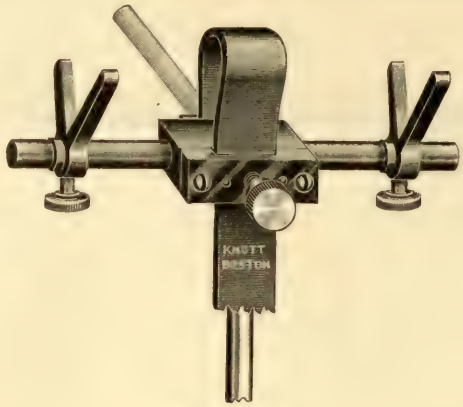
For **Complete Apparatus,** see Section **25.**



No. 5–915

5–915 **HAND BALANCE SUPPORT** or **CLAMP** for attaching to a Tripod Stand, and supporting adjustably a hand balance. This clamp is designed for use on a 13 millimeter rod. In use, a stiff tape, a shoestring being excellent, is threaded through the ring of the hand balance and then the ends threaded through the holes in the clamp, then wrapped once about the binding screw.

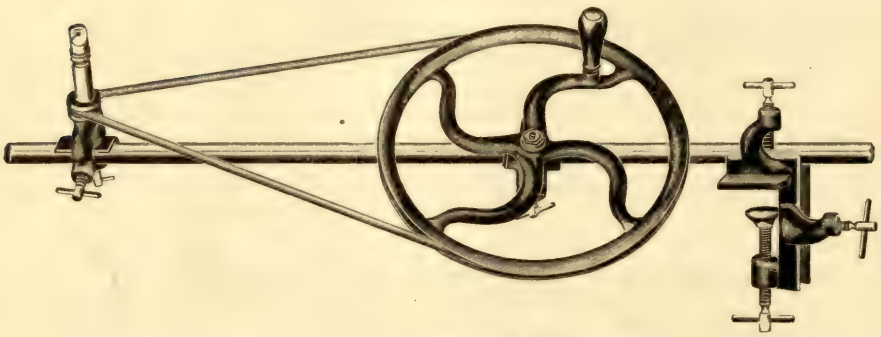
Height of the balance is readily adjusted, first (coarse adjustment), by position of clamp on the rod, second (fine adjustment), by drawing tape through the holes in the clamp. For clamp in use, see No. **15–225** **$0.35**



No. 5–920

5–920 TELESCOPE CLAMP, for holding any round or square object from 7.5 to 16 centimeters in length, especially designed for holding Reading Telescopes. This clamp is constructed of metal throughout, with clamping device consisting of two V's adjustable along the clamping rod to accommodate the different lengths of the objects. A strap adjustable to the size of the object is designed to bind it without danger of injury. The clamping rod is tapped ¼ by 20 on two faces to take the 10 millimeter rod, securing positions as may be noted in the illustration **$2.45**

MECHANICAL ROTATOR



Mounted horizontally

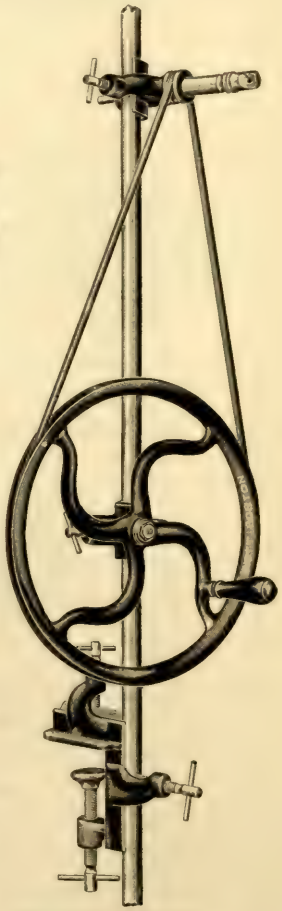
The accompanying illustrations show the method employed in setting up a Mechanical Rotator using the attachments listed below in conjunction with No. **5–350** Table Clamp and No. **5–20e** Support Rod.

5–925 MECHANICAL ROTATOR ATTACHMENTS, consisting of a Drive Wheel and Clamp and a Spindle and Clamp, the latter provided on one end with groove for belt, socket and set screw; on the other, with a special headed lock nut.
Drive Wheel and Clamp, Spindle and Clamp and Round Belt . . . **$5.35**

5–926 DRIVE WHEEL and **CLAMP,** including Round Belt **3.10**

5–927 SPINDLE and **CLAMP,** one end grooved for round belt and provided with socket and set screw; other with special headed lock nut **2.30**

5–928 ROUND LEATHER BELT with patent belt fastener . . . . . **.65**



Mounted vertically

MOUNTED PULLEYS, MIRRORS LENS HOLDERS, ETC.

No. 5–950

No. 5–952

No. 5–960

No. 5–970

No. 5–975

5–950 **PULLEY MOUNTED ON ROD,** axis at right angles to rod. Nickel plated, **BALL-BEARING, STEEL PULLEY,** 60 millimeters diameter, mounted in stirrup and attached to nickel-plated rod, 10 millimeters diameter, 15 centimeters long. This **MOUNTED PULLEY** must not be confused with the brass pulleys mounted on cone bearings, as by means of ball race we secure a frictionless pulley, running true, tested to uphold 150 pounds **$0.94**

5–952 **PULLEY MOUNTED ON ROD,** axis in same plane as rod: *i. e.*, pulley will run at right angles to rod. **BALL-BEARING PULLEY,** 60 millimeters diameter, mounted on nickel-plated rod, 10 millimeters diameter, 15 centimeters long, pulley tested to uphold 150 pounds . . . . . **.90**

5–960 **ADJUSTABLE PLANE MIRROR ON ROD.** Mirror 50 millimeters diameter, adjustable in stirrup about a horizontal axis, adjustable on rod about a vertical axis. Mounted on nickel-plated rod, 10 millimeters diameter, 15 centimeters long **1.95**

5–970 **UNIVERSAL LENS HOLDER,** for lenses up to 4 inches in diameter. This ingenious holder is adjustable by means of the rods and set screws to hold and clamp firmly in or off center, lenses up to 4 inches diameter. Handsomely oxidized black with nickel-plated rods **1.35**

5–975 ——, same as above, for holding lenses up to 2 inches in diameter **1.00**

BASES, SUPPORT RODS, CLAMPS

No. 5–990 LECTURE LIST "A"

A carefully selected list of bases, rods, clamps, and attachments, covering the essentials and designed for schools not in position to procure a more complete outfit:

Quan.	Number	Item
		SUPPORT BASES
2	**5–250**	Eccentric Leveling Bases
		SUPPORT RODS
1	**5–15b**	Support Rod 13 mm. × 40 cm.
1	**5–15c**	" " 13 mm. × 60 cm.
1	**5–20b**	" " 19 mm. × 40 cm.
1	**5–40b**	" " 19 mm. × 125 cm.
2	**5–20e**	" " 19 mm. × 100 cm.
		CLAMPS
2	**5–450**	Extension Clamps
2	**5–765**	Right Angle Clamps
2	**5–770**	Right Angle Clamps
1	**5–850**	Swivel Clamp
1	**5–895**	Meter Stick Clamp
1	**5–900**	Pendulum Clamp

Quan.	Number	Item
		MISCELLANEOUS
1	**5–540**	Platform
4	**5–646**	Hook Collars for 13 mm. rod
1	**5–950**	Pulley on rod
2	**5–952**	Pulleys on rod
1	**5–975**	Universal Lens Holder.
		T-BEAM BASIC CLAMPS
2	**5–1000**	Basic Clamps " A "
2	**5–1150**	Basic Clamps " B "
1	**5–1005**	Basic Rod Swivel Clamp
1	**5–1025**	Single Rod Attachment
1	**5–1030**	Three Rod Attachment
1	**5–1035**	Swivel Post Attachment
2	**5–1060**	Knife Edge Attachments
1	**5–1070**	Balance Cradle
1	**5–1080**	Pulley Clamp

5–990 **LECTURE LIST " A "** complete, as listed above . . . . . Set **$36.00**

(See next page)

BASES, SUPPORT RODS, CLAMPS

No. 5-995 LECTURE LIST "B"

The following list has been made up by teachers of long experience and is considered and advised by them as an equipment ample for lecture table demonstrations. The selection has been made with the intention of covering every need for the lecture table, with suitable bases, support rods, clamps, and attachments which will be needed in assembling and adjusting the apparatus used in the most complete lecture table demonstration courses. Suggestions for enriching this list either by new designs or by additions of old will be greatly appreciated.

SUPPORT BASES

Quan.	Number	Item
1	5-101	Tripod Base, 6 cm. for 10 mm. rod
2	5-105	" " 8 cm. for 10 mm. rod
1	5-114	" " 12 cm. for 10 mm. rod
2	5-115	" " 12 cm. for 10 mm. rod
1	5-140	" " 18 cm. for 19 mm. rod
1	5-170	" " 26 cm. for 30 mm. rod
4	5-250	Eccentric Leveling Bases, 11¼–18¼ inches
2	5-252	" " " 18½–32 inches

SUPPORT RODS

2	5-10b	Support Rods, 10 mm. × 15 cm.
2	5-10c	" " 10 mm. × 20 cm.
2	5-10e	" " 10 mm. × 40 cm.
2	5-15b	" " 13 mm. × 40 cm.
2	5-15c	" " 13 mm. × 60 cm.
2	5-15e	" " 13 mm. × 100 cm.
2	5-20b	" " 19 mm. × 40 cm.
2	5-20c	" " 19 mm. × 60 cm.
2	5-20e	" " 19 mm. × 100 cm.
1	5-20f	" " 19 mm. × 120 cm.
1	5-30d	" " 30 mm. × 120 cm.
1	5-40a	" " 19 mm. × 100 cm.
1	5-40c	" " 19 mm. × 185 cm.
1	5-50d	" " 19 mm. × 100 cm.
1	5-50e	" " 19 mm. × 120 cm.
1	5-400	Stand Tube, 20 cm. for 13 mm. rod
1	5-405	" " 30 cm. for 13 mm. rod
1	5-410	" " 30 cm. for 19 mm. rod
1	5-415	" " 40 cm. for 19 mm. rod

CLAMPS

2	5-360	Table Clamps
2	5-450	Extension Clamps
2	5-725	Right Angle Clamps
2	5-735	" " " V, 19 mm. hole 13 mm.
1	5-745	" " " V, 30 mm. hole 19 mm.
2	5-760	" " " 2 V's, 13 mm.
2	5-765	" " " 2 V's, 19 mm.
4	5-770	" " " 2 V's, 19 mm.
1	5-785	" " " V, 19 mm., tapped ¼ × 20
1	5-790	" " " V, 19 mm., tapped ⅜ × 16
5	5-810	" " " for optical bench
1	5-825	" " " for photometer
1	5-840	Universal Clamp
1	5-850	Swivel Clamp for 19 mm. rods
1	5-855	" " for 13 mm. rods
1	5-875	Universal Clamp
1	5-887	Adjustable Tube Clamp
1	5-889	Adjustable Arm

CLAMPS

Quan.	Number	Item
1	5-891	Rod V Clamp
1	5-895	Meter Stick Clamp
1	5-900	Pendulum Clamp
1	5-905	Bi-filar Pendulum Clamp

MISCELLANEOUS

1	5-510	Adj. Lab. Stand, 40–70 cm.
1	5-515	" " " 70–130 cm.
1	5-525	Platform, rod 10 mm., 7 × 8.5 cm.
1	5-527	" rod 19 mm., 7 × 8.5 cm.
1	5-530	" rod 10 mm., 8.5 × 11.5 cm.
1	5-535	" rod 13 mm., 8.5 × 11.5 cm.
1	5-540	" rod 13 mm., 11.5 × 15.5 cm.
1	5-545	" rod 19 mm., 14.5 × 21.5 cm.
1	5-260	Plate Base
1	5-480	Stand Top, 20 cm. for 13 mm. rod
1	5-485	" " 20 cm. for 19 mm. rod
1	5-490	" " 30 cm. for 19 mm. rod
1 pr.	5-375	End Supports
1 pr.	5-385	Secondary Supports
1 pr.	5-590	Knife Edge Brackets
1 set	5-610	Leveling Screws
1	5-635	Collar for 30 mm. rod
2	5-636	" for 19 mm. rod
1	5-637	" for 13 mm. rod
1	5-638	" for 10 mm. rod
6	5-645	Hook Collars for 10 mm. rod
10	5-646	" " for 13 mm. rod
4	5-950	Pulleys on rod
4	5-952	" on rod
1	5-960	Mirror on rod
1	5-970	Universal Lens Holder, lenses up to 4-in.
1	5-975	" " " " up to 2-in.

T-BEAM BASIC CLAMPS

4	5-1000	Basic Clamps "A"
2	5-1150	Basic Clamps "B"
2	5-1005	Basic Rod Swivel Clamps
1	5-1025	Single Rod Attachment
2	5-1030	Three Rod Attachments
1	5-1035	Swivel Post Attachment
2	5-1045	Secondary Basic Attachments
1	5-1050	Upright Secondary Attachment
1	5-1055	Meter Stick Attachment
2	5-1060	Knife Edge Attachments
4	5-1065	Stone's Tension Clamp Attachments
4	5-1070	Balance Cradle Attachments
1	5-1075	Micrometer Screw Attachment
1	5-1080	Universal Pulley Attachment
1	5-1085	Chladni's Plate Attachment
1	5-1185	Bench Anvil-Vise Attachment

5-995 LECTURE LIST, "B" complete, as listed above . . . . . Set **$173.00**

HARCOURT UNIVERSAL T-BEAM CLAMPS

The Harcourt Universal T-Beam Clamps have been so designed that they accomplish three very important results:

FIRST: They supply to the instructor a series of clamps which, with appropriate rods, will enable him to set up his apparatus in a minimum amount of time.

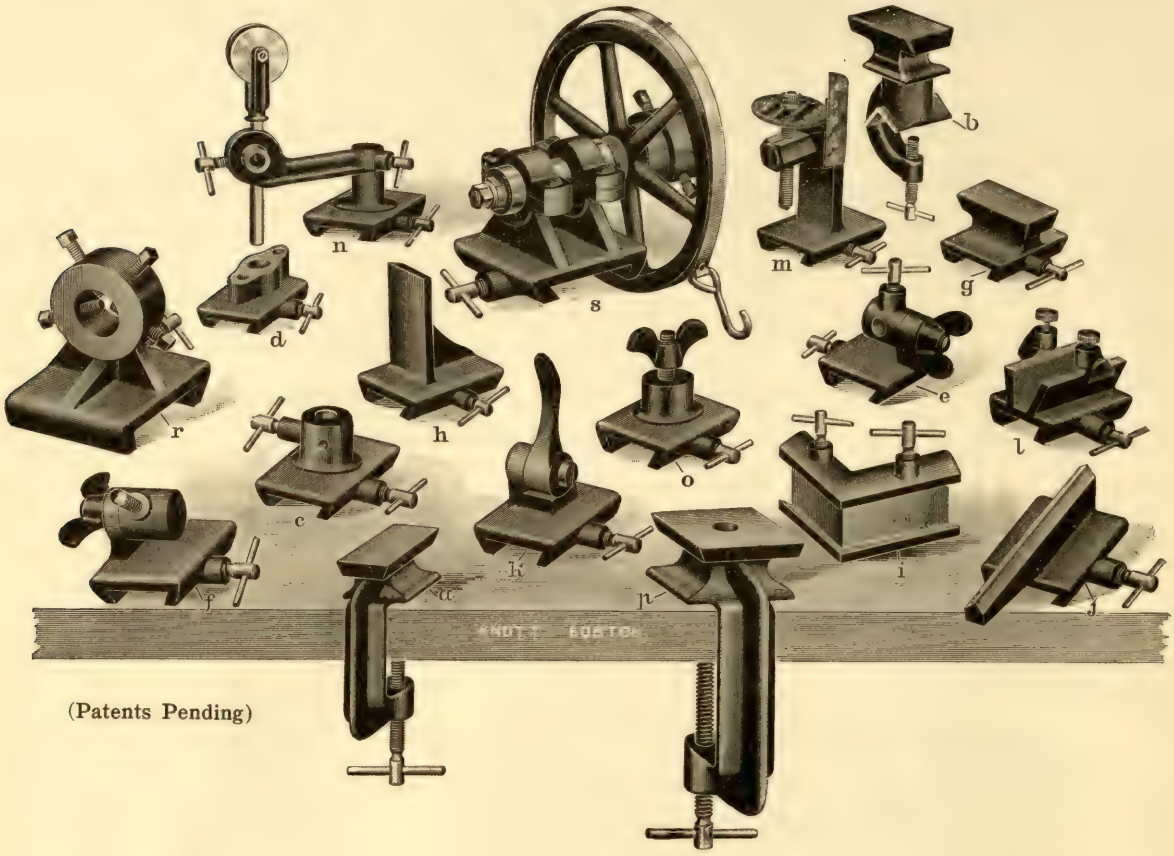
SECOND: They hold the apparatus, when so set up, correctly and rigidly.

THIRD: They do this at a reasonable cost.

The line which is listed in the following pages, with its lathe-rest interlocking attachment and interchangeable features, gives latitude of operation never before obtained with laboratory hardware.

The Harcourt Universal T-Beam Clamps are divided into two groups, Series "A" and Series "B." In the first series are two basic clamps: the Harcourt Universal T-Beam Basic Clamp "A" and the Basic Rod Clamp. To these basic clamps may be clamped the various Lathe-rest Interlocking Attachments. In Series "B" only one basic clamp is required, as this series is designed only for heavier work the nature of which would prohibit its use on a rod. The Lathe-rest Interlocking Attachments, therefore, in this series are few compared with those listed in Series "A."

Illustrations covering the vast utility of these series are practically impossible. We secure a greater range of usefulness and stability with our series than heretofore obtained by any other system of laboratory hardware. In our experiments, we have been able to cover practically the entire field of the "Interchangeable Laboratory Supports" by the few attachments which are herewith listed, widening the field and adding to the interchangeable features. If any position or "set-up" is desired that is neither illustrated nor can be procured with our line, we most urgently request the co-operation of the teachers in making known their particular needs.



(Patents Pending)

SERIES "A"

(Letters used in the following descriptions refer to corresponding letters in illustration above.)

5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "A" for clamping to a table or any surface not over 6 centimeters thick, as the fundamental support for attaching any of our Universal Lathe-rest Interlocking Attachments listed in this series. ("a" in illustration.) **$1.15**

5–1005 HARCOURT UNIVERSAL T-BEAM BASIC ROD SWIVEL CLAMP for clamping to any 13 or 19 millimeter rod for attaching any of our Universal Lathe-rest Interlocking Attachments listed in this series. ("b" in illustration.) As may be noted from the illustration of this clamp, it is in design similar to the Basic Clamp "A." It has a further important feature, however, impossible of adequate illustration. This feature allows of clamping the double bevel slide in any position without movement of the clamp along the rod. The universal movement is secured by means of an ingenious swiveled V-clamp device readily operated by the nickel-plated T-Screw **1.65**

UNIVERSAL LATHE-REST INTERLOCKING ATTACHMENTS

SERIES "A"

5–1025 **SINGLE-ROD ATTACHMENT** for holding a 10 millimeter rod either perpendicular or parallel to face of clamp. The rod is clamped rigidly in place by means of a nickel-plated T screw. (" c " in illustration.) In use, see Figs. **4** and **17** **$0.68**

5–1030 **THREE-ROD ATTACHMENT,** tapped ¼ × 20, ⅜ × 16, and ½ × 12, to hold either a 10, 13 or 19 millimeter rod. (" d " in illustration.) . . . . . **.66**

5–1035 **SWIVEL-POST ATTACHMENT** for clamping a 13 millimeter rod which may be swiveled through an arc of 180 degrees and fixed in any position by a wing nut. (" e " in illustration.) In use, see Adjustable Inclined Plane Support, Section **25;** also Figs. **15** and **18** . . . . . **.74**

5–1040 **THREADED SWIVEL-POST ATTACHMENT,** similar to above, but provided with a boss threaded to receive any rod tapped ⅜ × 16. (" f " in illustration.) In use, see Hand Air Pump, Section **42;** also Fig. **2** . . . . . **.74**

5–1045 **SECONDARY BASIC ATTACHMENT** for use in conjunction with Basic Clamp " A " to secure a lathe-rest support at right angles to that of the basic clamp. (" g " in illustration.) See Fig. **3** . . **.66**

5–1050 **UPRIGHT SECONDARY BASIC ATTACHMENT** for use in conjunction with Basic Clamp "A," lathe-rest slide perpendicular to clamp. (" h " in illustration.) See Fig. **3** . . . . . **.68**

5–1055 **METER STICK ATTACHMENT** for clamping a meter stick in an upright position. ("i" in illustration.) In use, see Fig. **1** . . . . . **.74**

5–1060 **KNIFE-EDGE ATTACHMENT.** ("j" in illustration.) In use see Knife Edge Clamp, Section **5;** Bending Beam Apparatus, Section **23;** also Figs. **12** and **14** . . . . . **.65**

5–1065 **STONE'S TENSION CLAMP ATTACHMENT.** ("k" in illustration.) In use, see Parallelogram of Force Apparatus, Section **24;** also, Figs. **8** and **10** . . . . . **.48**

5–1070 **BALANCE CRADLE ATTACHMENT,** designed for the standard 250, 500 or 2000 gram Spring Balances. ("l" in illustration.) In use, see Parallelogram of Force Apparatus, Section **24;** also Figs. **6, 9** and **16** . . . . . **.66**

5–1075 **MICROMETER SCREW ATTACHMENT,** swiveled split-post tension. ("m" in illustration.) For complete description, see Micrometer Screw, Section **12.** In use, see Flexure of Beams Apparatus, Section **23;** also Figs. **11, 13** and **14** **3.25**

5–1080 **UNIVERSAL PULLEY ATTACHMENT.** ("n" in illustration.) For complete description see Universal Pulley, Section **27;** also Figs. **19** and **20** **1.75**

5–1085 **CHLADNI'S PLATE ATTACHMENT.** ("o" in illustration.) In use, see Chladni's Figures Apparatus, Section **54;** also Fig. **5** . . . . . **.60**

SERIES "B"

(Letters used in following descriptions refer to corresponding letters in illustration opposite.)

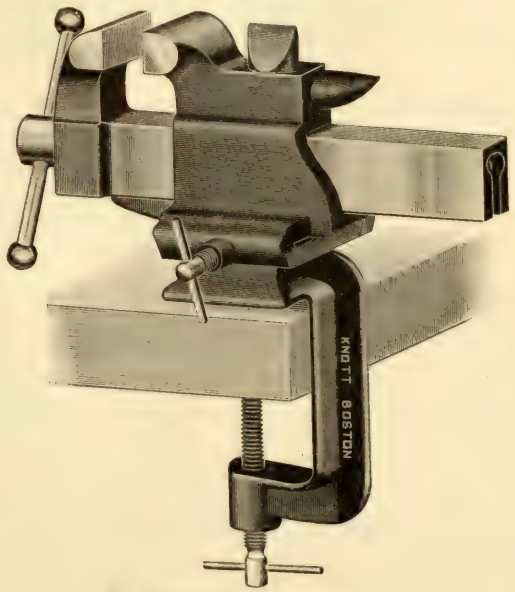
5–1150 **HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "B"** for clamping to a table or any surface not over 8½ centimeters thick as the fundamental support for attaching any of our Universal Lathe-rest Interlocking Attachments listed in this series. (" p " in illustration.) Attachments may be used in either direction **$1.90**

5–1175 **BALL-BEARING TORSION OF BEAMS ATTACHMENT.** ("s" in illustration.) In use and for description, see Torsion Apparatus, Section **23;** also Fig. **4** **3.90**

5–1180 **FIXED HEAD TORSION OF BEAMS ATTACHMENT.** ("r" in illustration.) In use and for description, see Torsion Apparatus, Section **23;** also Fig. **4.** May be used in four positions **1.35**

5–1185 **BENCH ANVIL-VISE ATTACHMENT,** interlocking with Basic Clamp "B" to secure a rigid, substantial bench anvil vise. Spread 5½ inches, jaws 2⅛ inches. Provided with hardened steel cutting-off tool **4.35**

5–1186 **BENCH ANVIL-VISE,** consisting of No. **5–1150** Basic Clamp and above attachment, complete **5.95**



No. 5–1186 Patent Pending

HARCOURT BASIC CLAMPS AND ATTACHMENTS

ILLUSTRATIONS

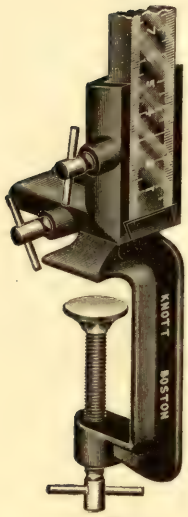


Fig. 1
Illustrating "a" and "i"
Supporting a meter stick
Patent Pending

Fig. 2
Illustrating "a" and "f"
With Hand Air Pump
Patent Pending

Fig. 3
Illustrating "a," "g" and "h"
Patent Pending

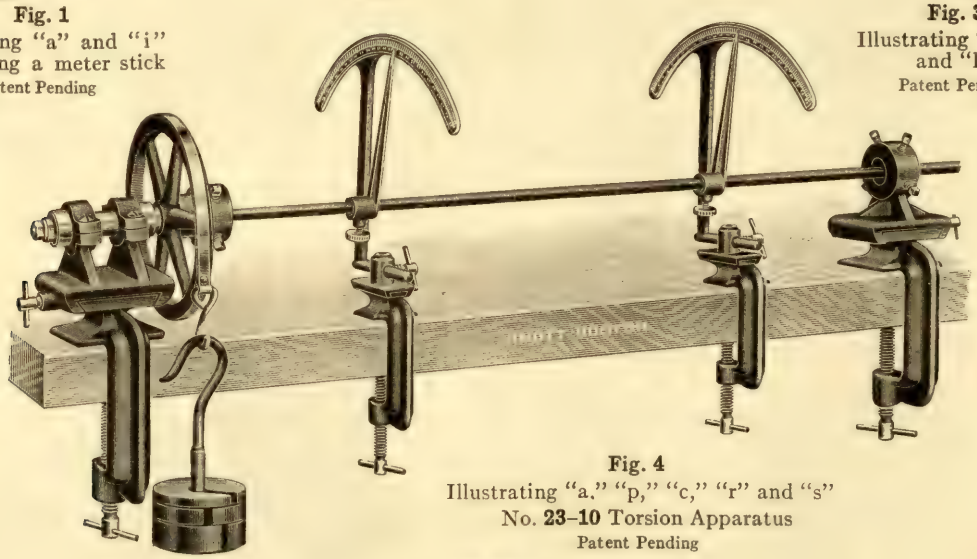


Fig. 4
Illustrating "a," "p," "c," "r" and "s"
No. **23–10** Torsion Apparatus
Patent Pending

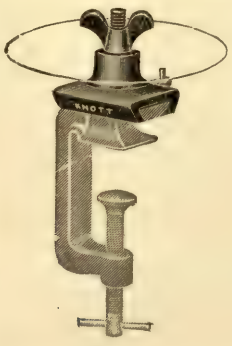


Fig. 5
Illustrating "a" and "o." Chladni's Plate Clamp
Patent Pending

HARCOURT BASIC CLAMPS AND ATTACHMENTS

ILLUSTRATIONS

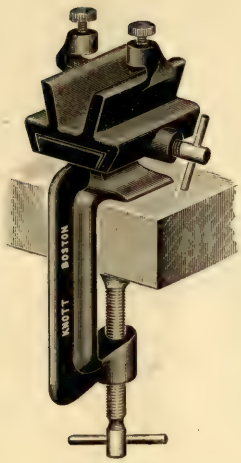


Fig. 6
Illustrating "a" and "l"
Patent Pending

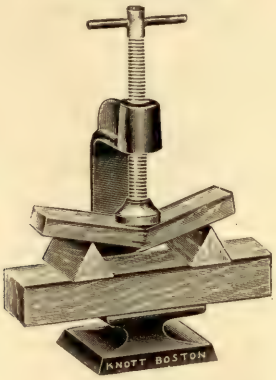


Fig. 7
Illustrating "p" used as No. **27-500** Jackscrew
Patent Pending

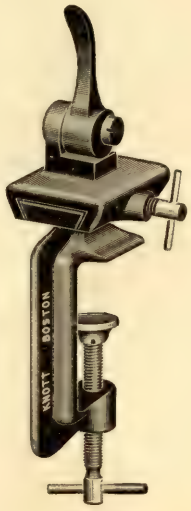


Fig. 8
Illustrating "a" and "k"
Patent Pending

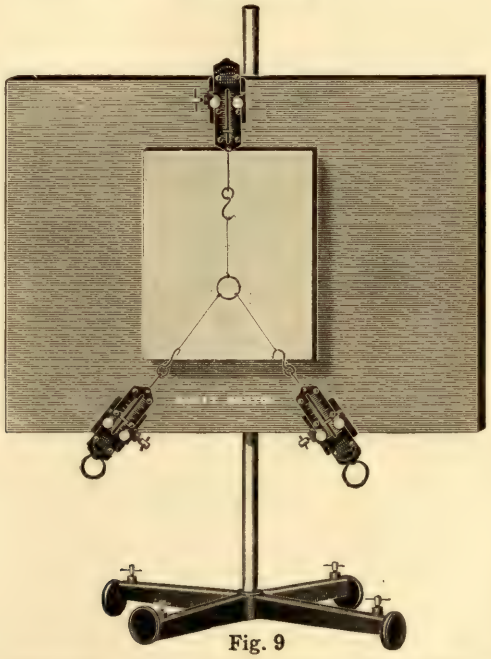


Fig. 9
Illustrating "a" and "l." Composition of Forces
Patent Pending

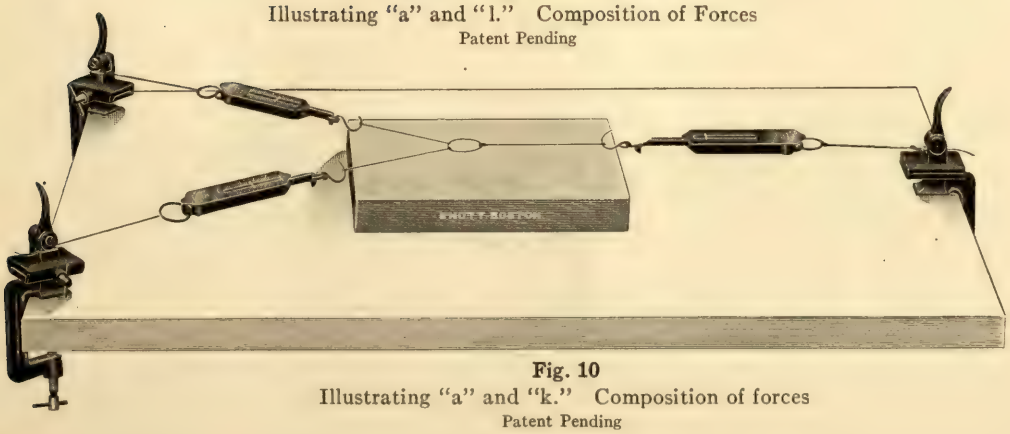


Fig. 10
Illustrating "a" and "k." Composition of forces
Patent Pending

HARCOURT BASIC CLAMPS AND ATTACHMENTS

ILLUSTRATIONS

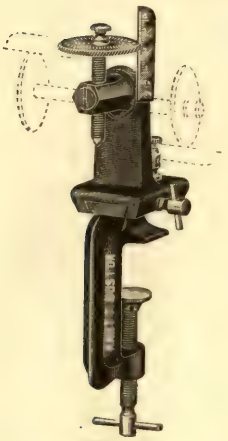


Fig. 11
Illustrating "a" and "m"
Front view
Patent Pending

Fig. 12
Illustrating "a" and "j"
Patent Pending

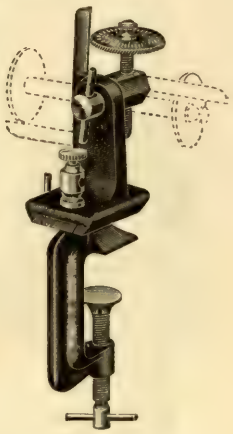


Fig. 13
Illustrating "a" and "m"
Rear view
Patent Pending

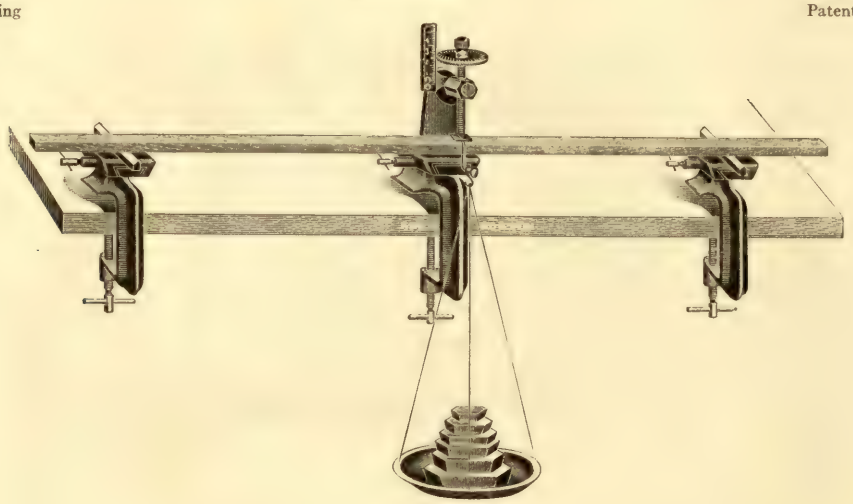


Fig. 14
Illustrating "a," "j" and "m." Flexure of Beams
Patent Pending

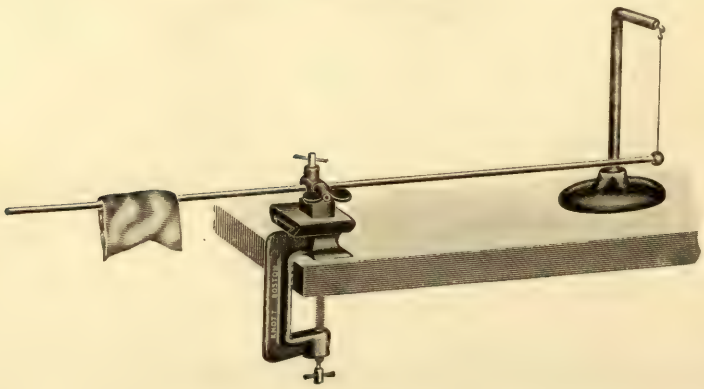


Fig. 15
Illustrating "a" and "e." Vibration of Rod
Patent Pending

HARCOURT BASIC CLAMPS AND ATTACHMENTS

ILLUSTRATIONS

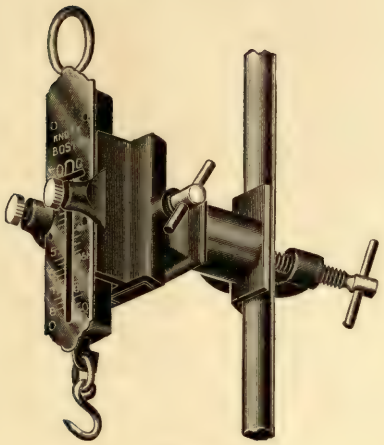


Fig. 16
Illustrating "b" and "e"
Patent Pending

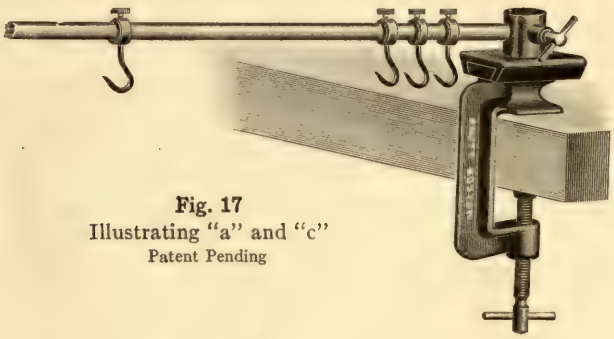


Fig. 17
Illustrating "a" and "c"
Patent Pending

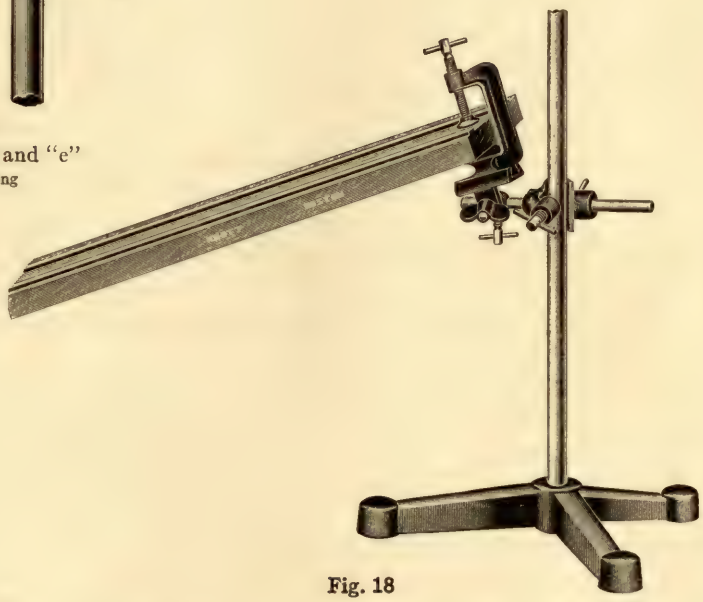


Fig. 18
Illustrating "a" and "e." Adjustable Inclined Plane Support
Patent Pending

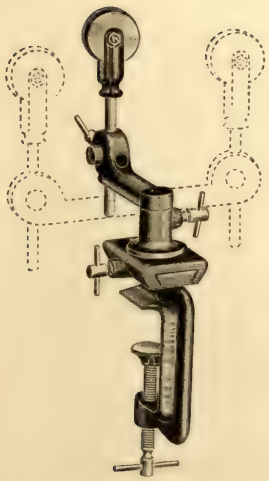


Fig. 19. Front View
Illustrating "a" and "n"
Universal Pulley
Patent Pending

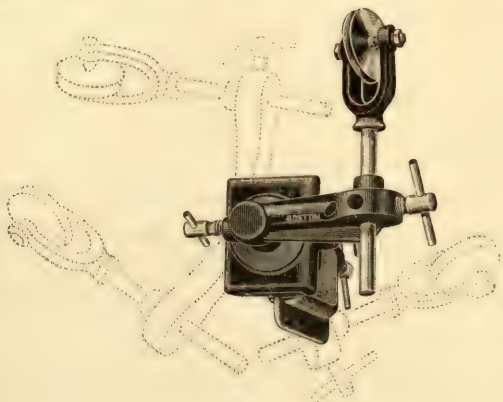


Fig. 20. Top View
Illustrating "a" and "n"
Universal Pulley
Patent Pending

DIRECTION SHEETS

For LOOSE-LEAF SYSTEM OF INSTRUCTION

By GEORGE M. TURNER and C. BROOKS HERSEY

Masten Park High School, Buffalo, N.Y.

Perhaps the most distressing problem confronting the science teacher, experienced or inexperienced, is that of the choice of a suitable laboratory guide for his classes. Requirements differ in each locality and in each school in that locality. These requirements are governed by many factors, principal among which may be cited the following, — some localities are manufacturing centers, some agricultural, in short, an industrial factor; some schools are not equipped to teach from any one manual guide, a condition arising perhaps from frequent changes of instructors, each of whom had individual methods instituting the personal tendency towards certain experiments, the new equipment thus ordered by him calculated to best conform to his methods, thus the factor of equipment. In this factor, also might be included the lack of equipment due to negligence of science instruction or lack of funds for proper equipment. Last, but not least, is the all-important factor of non-uniformity of College Entrance Requirements throughout the country.

Many instructors have solved the problem of meeting the individual school demands by formulating manual directions to meet their own particular conditions, but the matter has never been satisfactorily faced until Messrs. Turner and Hersey edited and authorized for publication the **LOOSE-LEAF NATIONAL PHYSICS NOTE-BOOK DIRECTION SHEETS.** In this publication, in which we have **SOLE SELLING RIGHTS,** a teacher is given a latitude for choice, and the extensive sale of these sheets has testified to their success in meeting the particular individual demand of the many who use them in preference to bound manuals.

The number of experiments covered up to the issuance of this catalogue is 131. In this list will be found, not only a latitude for choice of experiments but also for choice in method, thus meeting the demand for Manual Directions to conform to individual equipments. As this number is constantly increasing to keep pace with the advances made in science teaching, the **NATIONAL PHYSICS NOTE-BOOK WILL NEVER BECOME OBSOLETE.**

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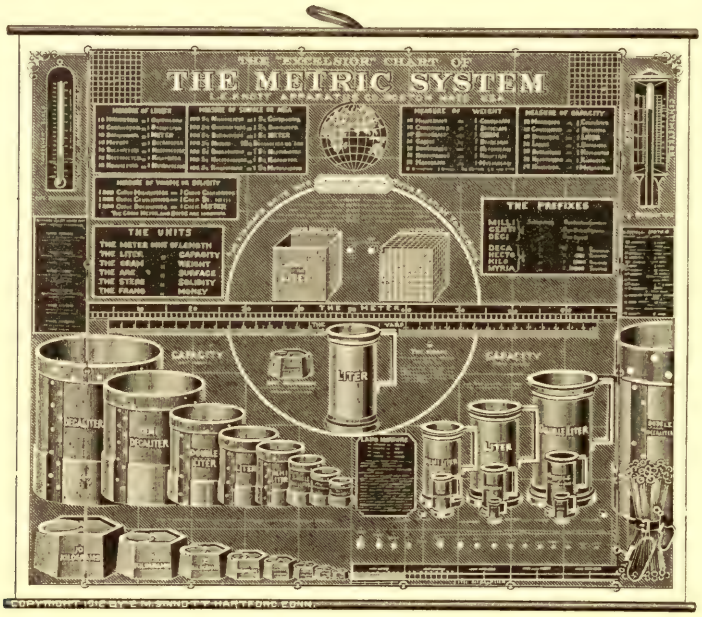

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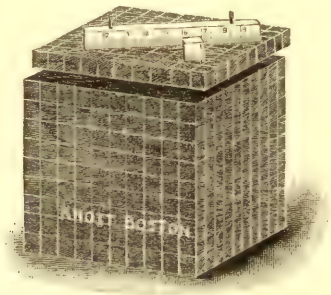
No. 10–10

10–10 METRIC CHART presenting graphically a comparative grouping of the Metric and English units of weights and measures.

The chart is 50 inches wide and 46 inches high, and the illustrations, beautifully lithographed in colors, are grouped in the best manner for direct comparisons of the two systems. The type is large and distinct and the coloring of the whole chart is such that it will be found not only a valuable, but an ornamental accessory to any laboratory.

Mounted on cloth back and provided with common rollers with hooks for hanging **$2.50**

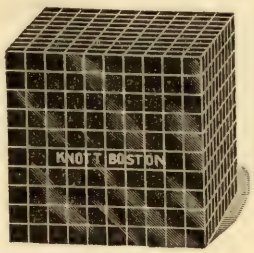


No. 10–20

10–20 LITER BLOCK, graduated, dissected, and **weighted** for the ocular as well as quantitative comparisons in the Metric System of length, area, volume, capacity, and weight.

This block is graduated, — one edge to millimeters, each face into square centimeters; dissectible to $\frac{1}{10}$, $\frac{1}{100}$, and $\frac{1}{1000}$ of its volume; weighted so that each section has a mass equal to an equivalent volume of water.

Made of selected hardwood, oil and wax finish, all graduations showing white **$3.00**

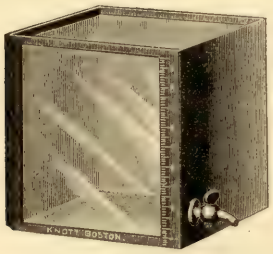


No. 10–25

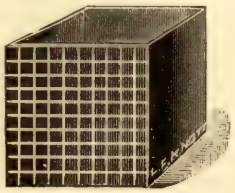
10–25 **LITER BLOCK,** for illustrative comparisons of units of length and volume in the Metric System.
This block is graduated as in No. **10–20** but neither loaded nor dissectible.
Made of selected hardwood, oil and wax finish, all graduations showing white **$1.15**

10–30 **LITER BLOCK** for illustration of size of one cubic decimeter (1000 cubic centimeters).
This block, not being graduated, dissectible, or weighted, does not have the same pedagogic value as the preceding yet will be found effective in the review of facts deduced by their use.
Made of hardwood with oil and wax finish . . . . . **.90**

NOTE. — Under No. 10–50 will be found listed a block accurately one foot on an edge. It will be found a valuable addition if ocular comparison of size of cubic liter and cubic foot is desired.



No. 10–35



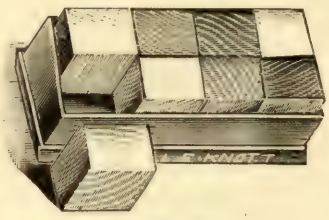
No. 10–45

10–35 **LITER CASE,** illustrating quantitatively metrical equivalents in measures of capacity, volume, and weight.
This case is constructed so that each edge measures 10 centimeters (one decimeter), having, therefore, a capacity of one cubic decimeter. It is especially adapted to the study of Archimedes' Principle and, applying this principle, to determining the specific gravity and volume of any irregular solid. This case is provided with glass face for inspection of contents of case, an accurate metal scale for measuring contents, and a stop-cock for inlet or outlet of water. By using a balance it may be determined that for every millimeter rise or fall of water as indicated by the scale the net weight varies by 10 grams, thus demonstrating that one gram of water occupies one cubic centimeter space.
Made of burnished copper with water-tight glass face, accurate metal scale and brass inlet cock . . . **$3.00**

10–40 **LITER CASE** with capacity for holding exactly one liter of water.
Accurately made of zinc, measuring one decimeter on edge internal measurement **1.10**

10–45 ——, same as No. **10–40** but with one face graduated into square centimeters. **1.60**

10–50 **CUBIC FOOT BLOCK,** furnishing for demonstrative work a striking illustration of the size and weight of a cubic foot of wood. Used also to advantage in density demonstrations.
Built up in sections to prevent warping and cracking, weight neatly printed in large type on one face **7.65**



No. 10–60

10–60 WOODEN CUBES, admirably adapted for work in density, offering also objects for simple measurements.

A set of eight cubes, each accurately 4 centimeters on an edge and each of different woods as follows: mahogany, satinwood, poplar, oak, boxwood, walnut, ebony, and lignum-vitae. Per set, in cardboard case **$3.30**

No. 10–70

No. 10–75

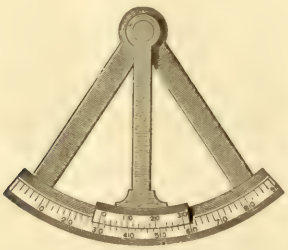
10–70 VERNIER MODEL for demonstration and study of simple vernier. Model has total length of 50 centimeters and is divided into 25 spaces of 2 centimeters each. Divisions and figures are clearly defined and large and may be seen across the ordinary lecture room.

Made of wood with sandpaper and oil finish **$1.60**

10–75 VERNIER CALIPER MODEL for demonstrative and quantitative work.

This Caliper Model is 30 centimeters long with graduations to centimeters. It is sufficiently accurate for most simple measurements, for the vernier will give readings to 1 millimeter.

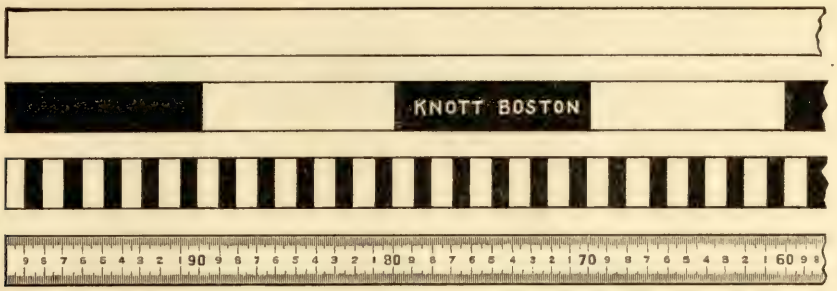
Made of clear grain boxwood neatly finished, metal slides nickel plated **2.75**



No. 10–80

10–80 VERNIER ARC MODEL, demonstrating principle of vernier arc in angle measurements.

This model is substantially made of hardwood with arc of 25 centimeters radius, vernier slides nicely and graduations are clearly and accurately made **$9.00**

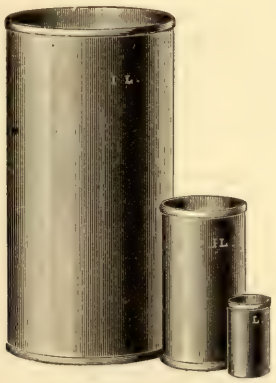


No. 10–85

10–85 **METER STICK** for teaching the general principles of linear measure in the Metric System.
This stick is a full meter in length and has a cross section measurement of 2 centimeters. First side is graduated into centimeters and millimeters; second, into centimeters only; third, into decimeters only; fourth, ungraduated. The second and third sides have further feature of having spaces painted alternate black and white **$1.50**

No. 10–100

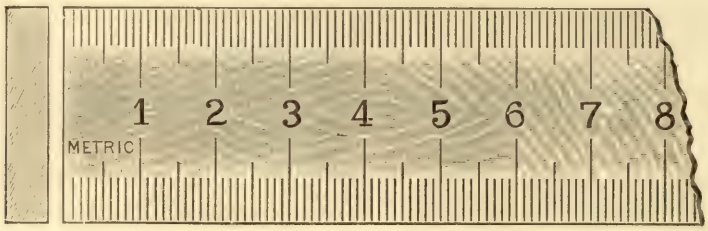
10–100 **LIQUID MEASURES** for quantitative measures of capacity and for illustrative teaching of units of capacity in the metric system.
Consists of seven measures, — one liter, and fractional parts of liter as follows: ½ liter, 2 deciliters, 1 deciliter, ½ deciliter, 2 centiliters, and 1 centiliter.
Made of burnished copper **$4.90**



No. 10–105

10–105 **LIQUID MEASURES,** consisting of liter, deciliter, and centiliter measures.
Made of burnished copper, same accuracy as in No. **10–100.** Set of three measures **$2.25**
10–110 **LIQUID MEASURES,** same as No. **10–100**, but made of tin and with the addition of a 2-liter measure. Set of eight measures **2.25**
10–115 **LIQUID MEASURE,** an accurate burnished copper liter measure **1.00**
10–120 **LIQUID MEASURE,** an accurate burnished copper quart measure. Useful in conjunction with any of the above measures in comparing units in Metric and English systems **1.00**

MEASURES OF LENGTH



No. 11–10

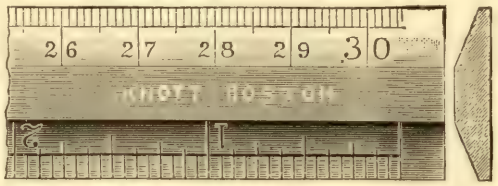
11–10 **METER STICK** of maple wood. Divided one side into fractional parts of foot and inch to 1/8 inch; other side into fractional parts of meter and centimeter to millimeters $0.30

11–11 ——, same as above, but with ends tipped with brass 35

11–15 **HALF-METER STICK,** same quality as No. **11–11.** Tipped with brass. 28

11–20 **DOUBLE-METER STICK,** same quality as No. **11–11.** Tipped with brass 1.35

11–40 **METRIC RULE** of maple. This is a convenient 10 centimeter length cut from a meter stick and will be found of great utility in many experiments 07



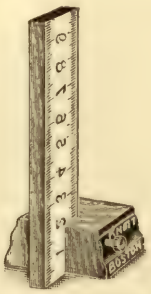
No. 11–50

11–50 **DOUBLE BEVEL BOXWOOD RULE,** Metric and English Scales, with 1/4 inch blank ends. On Metric bevel 30.5 centimeters are divided to millimeters; on English, 12 inches to sixteenths. Rule is 12½ inches long, 7/8 inches wide, and 3/16 inch thick. Excellent quality . . . . . Each $0.12
Per doz. 1.40

11–55 **DOUBLE BEVEL MAPLE RULE,** Metric and English Scales as in No. **11–50** . . . . . Each .04
Per doz. .40

No. 11–65

11–65 **TRIANGULAR BOXWOOD RULE AND SCALE,** indispensable for rapid drawing to scale or in calculating actual dimensions from scale drawings.
This Rule and Scale has the merit of having six different surfaces for graduation, and there are offered ten different scales to the foot: 3/32, 3/16, 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1½, and 3 inches to the foot. One edge graduated to sixteenths of an inch.
Made of boxwood, hand polished, 12½ inches long with 1/4 inch blank ends $0.55



No. 11–70

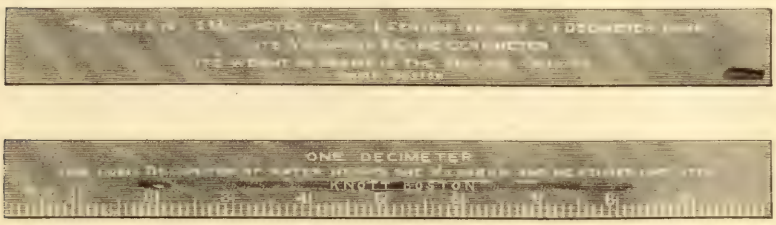
11–70 **VERTICALLY MOUNTED RULE.** Used frequently with indicating lever in bending experiments $0.16

11–80 **STRAIGHT-EDGE RULE,** especially designed for the drawing of diagrams; useful in light experiments and many other experiments chiefly in Mechanics.
Made of light, clear-grain selected stock . . . . . Per Pair .16

No. 11–100

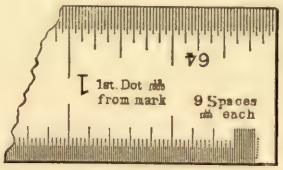
11–100 STANDARD STEEL RULES, Metric and English Scales subdivided with greatest care and accuracy. The 5 and 10 centimeter rules listed are divided as follows: first corner graduated to ½ millimeter; second, to 1 millimeter; third, to 1/64 inch; fourth, to 1/100 inch. The remaining listed rules: first corner, to ½ millimeter; second, to 1 millimeter; 2 inches of third, to 1/64 inch, the remainder to 1/16 inch; 2 inches of fourth, to 1/100 inch, the remainder to 1/50 inch.

	a	b	c	d	e	f
Length	5	10	20	30	50	100 centimeters
Each	**$0.30**	**.55**	**1.00**	**1.35**	**2.25**	**7.50**



No. 11–105

11–105 DECIMETER STEEL RULE, "A Key to the Metric System." This rule is accurately graduated to millimeters and in addition has the pedagogic merit of being exactly 10 centimeters long, 1 centimeter wide, and 1/10 centimeter thick. The volume, therefore, being exactly 1 cubic centimeter, the weight of this rule will be the specific gravity of steel. Marked also on the other side of this rule is the fact that "One cubic decimeter of water weighs one kilogram and measures one liter."
Each rule sent in metal-bound leather case **$0.60**



No. 11–110

11–110 IMPROVED STANDARD STEEL RULES, graduated first corner to 16ths of an inch, second corner to 32ds, third to 64ths, and fourth to 100ths. Improved by series of graduations at end of scale of hundredths as follows: nine spaces of 11/1000 of an inch, and the diagonal line of dots, the one nearest the edge of the rule being 12/1000 of an inch from the last line, each dot being 1/1000 of an inch nearer the line than the one immediately following. Any length from 1/10 of an inch to range of scale is therefore possible by 1/1000 of an inch.

	a	b	c	d	e	f	g
Length	3	4	6	9	12	18	24 inches.
Each	**$0.45**	**.60**	**.85**	**1.25**	**1.75**	**2.50**	**3.15**

No. 11–115

11–115 TRIANGULAR STEEL RULE, graduated with greatest care and accuracy. One side graduated to 16ths of an inch, second to 64ths, and third to 100ths.

	a	b	c	d
Length	3	4	6	12 inches.
Each	**$0.65**	**.90**	**1.25**	**2.60**

No. 11–130

11–130 CELLULOID RULE, Metric and English, 6 inches long, with distinct black-filled accurate divisions showing clearly on the white celluloid.
The adaptability of these rulers as book markers and to the vest pocket and their flexibility to manifold usage has fully warranted their popularity . . . . . Each **$0.05**
Per Doz. **.60**

L. E. KNOTT APPARATUS CO., Boston, Mass.
LABORATORY EQUIPMENT
For accurate and rapid measurement of flat surfaces this scale is superior to the wood rule.
Estimates to the tenth m. m. may be made with reasonable accuracy.

No. 11–135

11–135 BRISTOL BOARD METRIC RULE, generally useful but especially adapted to measuring curved surfaces.
Twenty centimeters long, graduated to millimeters with margin on either end of about 20 millimeters.
Per 100 **$0.90**

No. 11–140

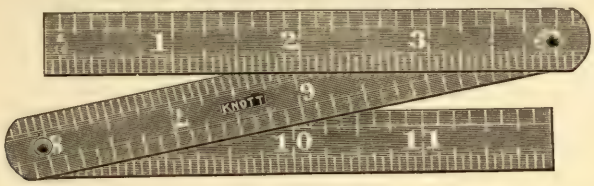
11–140 BRISTOL BOARD DIAGONAL SCALE, very carefully divided, will read accurately to 1/10 millimeter.
Length 16 centimeters . . . . . Each **$0.03**
Per 100 **2.50**

No. 11–145

11–145 BRISTOL BOARD COMPARING SCALE, for rapid determinations of Metric and English linear equivalents.
Fifty centimeters long, engine divided **$0.20**
11–160 PAPER METRIC RULE, 20 centimeters long, same as No. **11–135** but of heavy bond paper . . Per 100 **.67**
11–165 PAPER METRIC SCALE, 100 centimeters long, graduated to millimeters. Accurately printed on heavy bond paper . . . . . Each **.10**

No. 11–175

11–175 STANDARD METER, graduated throughout entire length to millimeters, attaining highest possible accuracy at 18 degrees Centigrade.
Graduated on brass and included in neat case . . . . . Duty Free **$30.00**
11–177 STANDARD METER. Same as No. **11–175,** one decimeter graduated to millimeters, remainder to centimeters.
Including neat case . . . . . Duty Free **21.50**



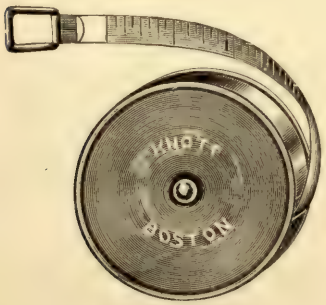
No. 11–185

11–185 **FOLDING STEEL POCKET RULE,** Metric and English Scales, engine divided, polished surface, with black, distinct figures and graduations. Graduated to millimeters on one side, to inches and sixteenths on the other.
Length one foot, ⅜ inches wide, No. 28 gauge steel, folding to 4 inches.
Enclosed in metal-bound leather case **$0.50**

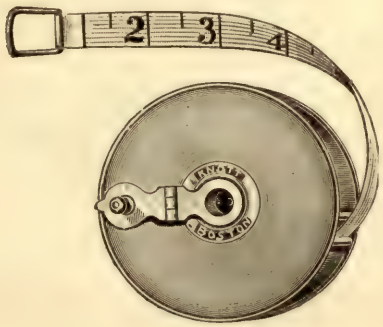
No. 11–195

11–195 **THUMB-SLIDE STEEL RULE,** useful in measuring against a shoulder, widths, etc. The slide, formed to fit the thumb may be used from either edge or removed and rule used alone.
Length 6 inches, width about 9/16 inch, thickness about 1/16 inch.
First corner graduated to 32ds; second, to 48ths; third, to 50ths; fourth, to 54ths of an inch . . . **$1.25**

11–197 **THUMB-SLIDE STEEL RULE,** same as above, but graduated on three corners to millimeters, and on one corner to ½ millimeter **1.25**



No. 11–215



No. 11–220

11–215 **STEEL POCKET MEASURING TAPE, METRIC AND ENGLISH,** spring wind, with stop, German silver case.
Graduated to inches and sixteenths on one side, to millimeters on the other. Length 1 meter . . . **$0.95**

11–216 ——, same as above, but 5 meters long **3.90**

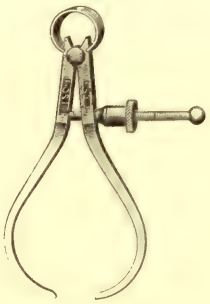
11–220 **LINEN POCKET MEASURING TAPE, METRIC AND ENGLISH,** waterproof-coated ½ inch corded tape, in brass-bound case with brass folding handle, brass ring and trimmings.
Marked feet and inches one side; meters and centimeters other side. Length 10 meters . . . . . **.67**

11–221 ——, same as above, but 25 meters long **1.35**

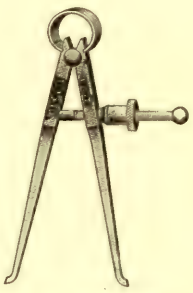
MEASURING INSTRUMENTS

Calipers, Micrometers, Verniers, Spherometers, Gauges, etc.

Nos. 12–10 to 12–11



Nos. 12–25 to 12–26



Nos. 12–27 to 12–28

12–10 **COMBINATION, OUTSIDE AND INSIDE CALIPERS,** polished steel. Length 4 inches **$0.20**

12–11 ——, same as above, but 6 inches long . . . . . **.25**

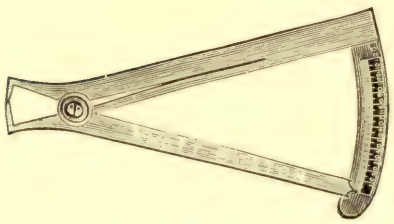
For other Calipers see Index.

12–25 **OUTSIDE SPRING CALIPER,** extra quality polished steel machinist's caliper. Length 4 inches . . **.80**

12–26 ——, same as above, but 6 inches long . . . . . **.90**

12–27 **INSIDE SPRING CALIPER,** extra quality polished steel machinist's tool. Length 4 inches . . . **.80**

12–28 ——, same as above, but 6 inches long . . . . . **.90**



Nos. 12–35 to 12–36

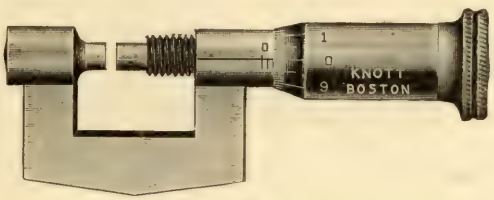
Nos. 12–40 to 12–42

12–35 **SPRING GAUGE CALIPER,** indispensable for the measuring of thicknesses of lenses, sufficiently accurate for ordinary laboratory measurements of sheet metal and wire. Rapid and accurate, reading directly to $\frac{1}{10}$ millimeter. Measuring up to 10 millimeters **$1.50**

12–36 **SPRING GAUGE CALIPER,** same as above, but measuring up to 14 millimeters **1.81**

12–40 **CALIPER GAUGE** for measuring thickness of plates, boards, etc., within range of $\frac{1}{40}$ to $1\frac{7}{8}$ inches, the range of the caliper. Slide rod is graduated on opposite sides, one side reading 32ds, the other 40ths of an inch. All readings are made from the top of the knurled friction slide, and when in operation the contact ends of the gauge are brought together against the object being measured, the measuring rod may be removed from the hook part and the whole taken to the light and the correct measure indicated above the friction slide easily taken **2.50**

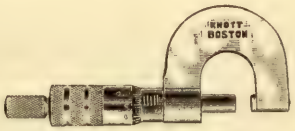
12–42 **CALIPER GAUGE,** same as above, but graduated in Metric System. Capacity 47 millimeters, rod graduated on one side into millimeters, on the other into $\frac{1}{2}$ millimeters **2.60**



No. 12–75

12–75 **MICROMETER CALIPER,** Metric measure, best quality, accurate steel screw, polished steel frame with friction head, — an improved method of securing the same degree of pressure on all objects to be measured. Measures all sizes from 0 to 18 millimeters by 1/100 millimeter **$3.30**

12–76 **MICROMETER CALIPER,** same as above, but furnished in neat leather case **3.80**



Nos. 12–80 to 12–90

12–80 **MICROMETER CALIPER,** Metric measure with Ratchet Stop, — an improved method of securing the same degree of pressure on all objects to be measured. Will measure from 0 to 13 millimeters by .01 millimeter **$5.00**

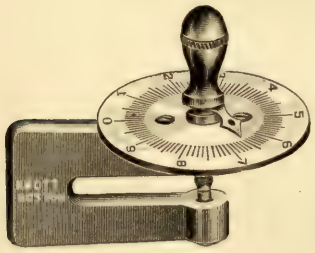
12–82 **MICROMETER CALIPER,** English measure with Ratchet Stop. Will measure from 0 to ½ inch by .001 inch **5.00**

12–84 **MICROMETER CALIPER,** Metric measure with Ratchet Stop. Will measure from 0 to 25 millimeters by .01 millimeter **6.50**

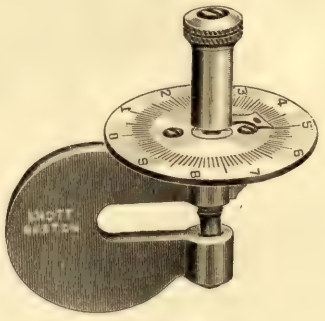
12–86 **MICROMETER CALIPER,** English measure with Ratchet Stop. Will measure from 0 to 1 inch by .001 inch **6.50**

12–88 **MICROMETER CALIPER,** English measure with Ratchet Stop. Will measure from 0 to ½ inch by .001 inch and also .0001 inch **6.50**

12–90 **MICROMETER CALIPER,** English measure with Ratchet Stop. Will measure from 0 to 1 inch by .001 inch, and also by .0001 inch **7.40**



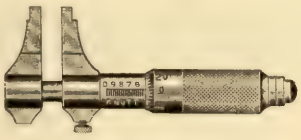
No. 12–95



No. 12–97

12–95 **MICROMETER CALIPER** for measuring the thicknesses of thin plates, also diameters of wires. This instrument consists of a graduated disc, 45 millimeters diameter, with pointer. Will measure thicknesses and diameters up to 5 millimeters by 1/100 millimeter. Handsomely nickel plated . . **$6.65**

12–97 **MICROMETER CALIPER,** similar to above, but provided with Friction Head **7.15**



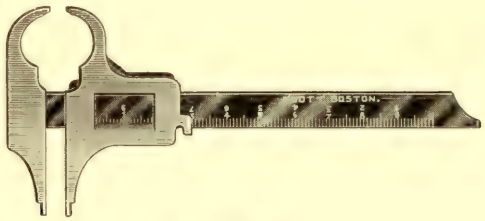
No. 12–105

12–105 **INSIDE MICROMETER CALIPER,** Metric measure, devised for measuring the diameters of small holes or tubes with greater accuracy than can be obtained with dividers or inside gauge. Will measure from 5 to 25 millimeters by 1/100 millimeter. Provided with clamp screw to preserve the setting **$5.60**

No. 12–140

12–140 SLIDING CALIPER, English and Metric measures, of boxwood, with ivory sliding scale. Will measure up to 3 inches by 16ths, or up to 72 millimeters by millimeters. Finer estimations possible **$1.10**

Models for the illustrative demonstration of principle of Verniers will be found listed in Section **10.** For accurately working model of Vernier Caliper see No. **10–70.**



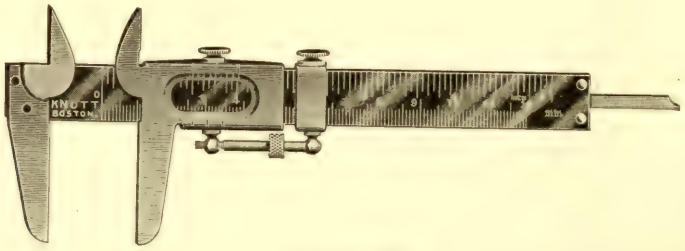
No. 12–155

12–155 VERNIER CALIPER, Metric measure, generally useful in outside, inside, and depth measurements. In use as outside caliper either square or caliper jaw may be used. In use as inside caliper, read as for outside caliper and subtract 2 millimeters for width of the points. In reading for depth measurement use upper row of figures and other end of vernier. Range 0 to 10 centimeters.
Made of polished steel **$2.15**

No. 12–160

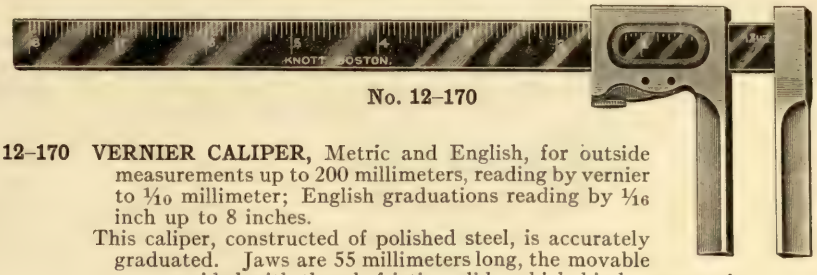
12–160 VERNIER CALIPER, Metric and English measures with Verniers for each. Outside, inside, and depth measurements each possible with great accuracy. Will measure objects up to 10.7 centimeters by $\frac{1}{10}$ millimeter, or up to $4\frac{1}{4}$ inches by $\frac{1}{128}$ of an inch.
Made of polished steel and provided with thumb knob and set screw **$2.20**

12–161 VERNIER CALIPER, same as above, in neat leather case **2.45**



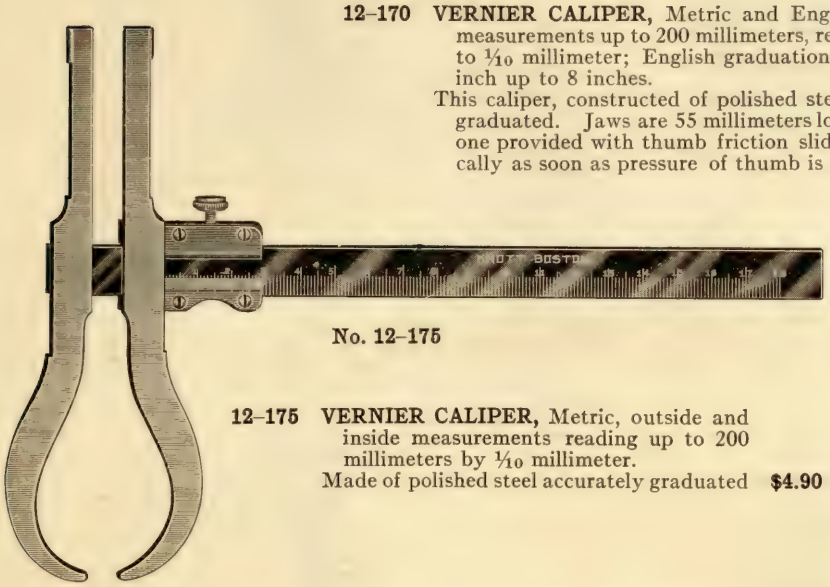
No. 12–165

12–165 VERNIER CALIPER, same as No. **12–160,** but with addition of micrometer screw adjustment. In neat leather case **$3.70**



No. 12–170

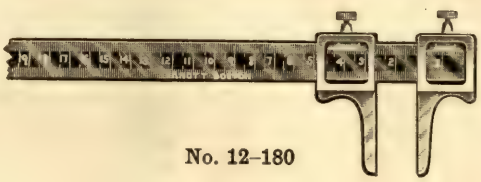
12–170 VERNIER CALIPER, Metric and English, for outside measurements up to 200 millimeters, reading by vernier to $\frac{1}{10}$ millimeter; English graduations reading by $\frac{1}{16}$ inch up to 8 inches.
This caliper, constructed of polished steel, is accurately graduated. Jaws are 55 millimeters long, the movable one provided with thumb friction slide which binds automatically as soon as pressure of thumb is removed **$4.60**



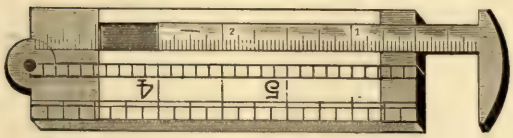
No. 12–175

12–175 VERNIER CALIPER, Metric, outside and inside measurements reading up to 200 millimeters by $\frac{1}{10}$ millimeter.
Made of polished steel accurately graduated **$4.90**

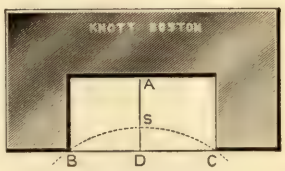
12–180 CALIPER ARMS, Bonnell design, for use with Meter Stick in assembling a Vernier Caliper of large range.
These arms are smooth metal castings made to fit the standard Meter Stick. One arm is designed for setting at some point arbitrarily selected as the zero of the Meter Stick, while the other carries two verniers, one to read to $\frac{1}{40}$ of an inch on the English side, the other to read to $\frac{1}{10}$ millimeter on side with Metric divisions.
Vernier arms only, neatly nickeled, per pair . . **$2.85**



No. 12–180



No. 12–185



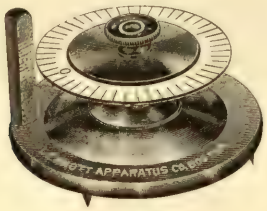
No. 12–190

12–185 CALIPER RULE, for use as a folding pocket rule and caliper. Rapid caliper measurement possible where accuracy not greater than $\frac{1}{32}$ inch is desired.
Two fold, brass bound, brass slide, boxwood caliper rule, slide graduated to $\frac{1}{32}$, rule to 8ths, 10ths, 12ths, and 16ths of an inch. Total length possible, 6 inches **$0.45**

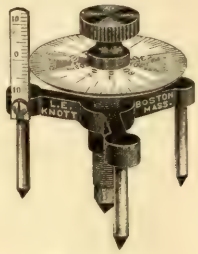
12–187 CALIPER RULE, same as above, but four fold and 12 inches long . . . . . **.55**

12–190 CYLINDROMETER for measuring diameters of spheres and cylinders from 4 centimeters upwards. With directions . . . . . **.90**

12–200 VERNIER CALIPER MODEL for demonstrative and quantitative work.
This Caliper Model is 30 centimeters long with graduations to centimeters. It is sufficiently accurate for most simple measurements, for the Vernier will give readings to one millimeter.
Made of clear grain boxwood, neatly finished, metal slides, nickel plated. For illustration, see Section **10** **2.75**



No. 12–205

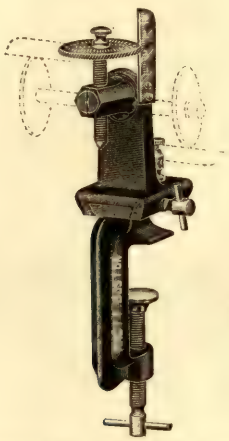


No. 12–210

12–205 **SPHEROMETER** for measuring curvature of lenses, mirrors, etc. Steel screw accurately 1 millimeter pitch, silvered brass head 2 inches in diameter graduated into 50 parts. Legs cover surface of 25 millimeters radius. Will measure surfaces of 5 millimeters concavity or convexity. Reads directly to $\frac{1}{50}$ millimeter, but as divisions on head are approximately 3 millimeters apart, estimations to $\frac{1}{200}$ are readily possible **$5.90**

12–210 **SPHEROMETER,** inexpensive, serviceable form, reading directly to $\frac{1}{100}$ millimeter. Concave measurements to 5 millimeters, convex up to 15 millimeters **3.30**

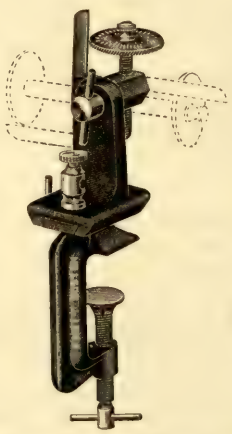
12–216 **SPHEROMETER, FRICTION HEAD,** concave and convex readings up to 20 millimeters by $\frac{1}{1000}$ millimeter. Excellent quality, accurate screw, nicely graduated, neatly finished . . Duty Free **11.25**



Patent Pending

Showing front view of attachment

No. 12–225



Patent Pending

Showing rear view of attachment

12–225 **HARCOURT UNIVERSALLY-ADJUSTABLE T-BEAM MICROMETER SCREW** for general application in laboratory practice where a micrometer screw is needed.

The above illustration represents a form of Micrometer Screw originated by us for attachment to our No. **5–1000** Harcourt Universal T-Beam Clamp "A." This attachment consists of a casting carrying a swiveled overhanging bracket holding in split-post tension an accurately threaded millimeter screw. The whole is so designed as to permit facing of the screw in either direction and turning the screw in any position in a vertical plane, and a back-and-forth adjustment on the bed of the Basic Clamp. In any of these positions the attachment, screw, and Basic Clamp may be interlocked by the nickel-plated T screws as one rigid instrument.

The Head of the screw is 45 millimeters in diameter and is divided into 100 parts. The Screw is accurately threaded 1 millimeter pitch, thus making possible a reading to $\frac{1}{100}$ millimeter.

HARCOURT UNIVERSALLY-ADJUSTABLE T-BEAM MICROMETER complete as illustrated including Micrometer Screw Attachment and No. **5–1000** Harcourt Universal T-Beam Basic Clamp "A" **$4.40**

12–227 **HARCOURT UNIVERSALLY-ADJUSTABLE MICROMETER SCREW ATTACHMENT** only for use with our No. **5–1000** Harcourt Universal T-Beam Basic Clamp "A" **3.25**

12–228 **HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "A,"** same as No. **5–1000** illustrated above in connection with No. **12–225** **1.15**

12–230 **MOUNTED MICROMETER SCREW.** This is a carefully designed instrument. The Stand is massive, provided with three milled legs insuring stability and a position in true plumb with the plane of the table. The Screw is accurately threaded 1 millimeter pitch and is provided with a head 45 millimeters in diameter divided into 100 parts, thus reading to $\frac{1}{100}$ millimeter. It is mounted in a split-post tension in an overhanging bracket. Binding screw is provided for electrical connection. Handsomely finished throughout **2.90**

No. 12–250

12–250 COMPENSATING PLANIMETER, simple pattern for measuring mechanically, yet most easily and accurately, the area of any plain figure, preferably one of an irregular outline.

The instrument consists of the Pole, — a needle point projecting from the lower side of the brass cylinder "p." This pole is connected to the tracing frame by means of the Polar Arm "P," — the junction of the Tracing Arm being made by a Ball Pin "G" and a Socket in the frame. The essential parts of the Tracing Frame are the Roller "M" and Tracing Point "f." As the Tracing Point "f" is made to trace the outline of the figure, the Roller is caused to revolve and it is by the extent of these revolutions that the area of the traced figure is ascertained. The Revolving Device consists of a Drum attached to the Roller. This Drum is divided into 100 parts, one of which indicates 0.10 square inch. These single parts may be read to tenths by means of the Vernier. The Counting Disc "Z" indicates complete revolutions, each division on the disc corresponding to one revolution of the roller. Thus, it may be seen that any position of the counting device may be written down in vernier units in four figures.

In use, it is only necessary to note reading of the roller before tracing the figure; note after tracing; deduct first from second and multiply the difference by 0.01. The figure resulting gives the number of square inches of area.

Each instrument receives the greatest care in its construction and the workmanship and finish will satisfy even the most critical. Each instrument is enclosed in plush-lined leather case, and with each is sent complete directions for care and use . . . . . Duty Free **$14.75**

No. 12–275

Front Side No. 12–280

Reverse Side No. 12–280

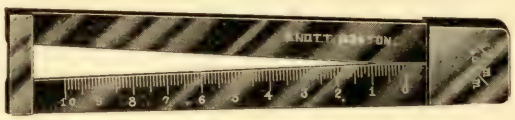
12–275 AMERICAN STANDARD WIRE GAUGE, made of best steel, tempered, adjusted and warranted accurate. Decimal equivalents expressed in thousandths, stamped on back opposite regular gauge numbers. Sizes 0 to 36 . . . . . **$2.90**

12–277 ——, same as above, sizes 5 to 36 . . . . . **2.20**

12–280 POCKET SCREW AND WIRE GAUGE, for measurements of wire as well as machine and wood screws. On front side of left of slot, this gauge is graduated to show all sizes of the American Standard Screw Gauge from 0 to 30; on other side of slot, equivalent fractions of an inch are marked. The edge of the gauge is graduated to 32ds and 16ths. The back side is graduated on right of slot from 17 to 0000 as the old or English wire gauge; on the left from 15 to 0000 as the new or American wire gauge. The angle cut in the side allows the head of a screw to be placed in a positive stop when measuring the length **2.95**

No. 12–295

12–295 TAPER GAUGE, for inside measurements of tubes, holes, etc. Made of hardened polished steel and about 18 centimeters long; will measure from 1/10 to 15 millimeters **$0.80**



No. 12–300

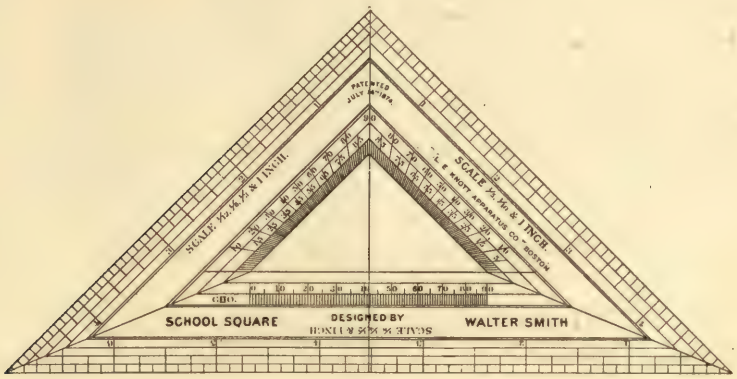
12–300 TAPER GAUGE, for outside measurements of rods, etc. Made of polished hardened steel about 15 centimeters long; will measure all diameters from 1/10 to 10 millimeters **$1.65**

WIRE GAUGES

The Brown and Sharpe (B. & S.) Gauge or American Wire Gauge (A. W. G.) as it is sometimes called, is generally used in this country. Other gauges and their comparative diameters are also given in the following table, dimensions of wires being given in decimal parts of an inch.

Number of Wire Gauge	American or B. & S.	Birmingham or Stubs	Washburn & Moen Mfg. Co. Worcester	British Standard	Number of Wire Gauge	American or B. & S.	Birmingham or Stubs	Washburn & Moen Mfg. Co. Worcester	British Standard
0000	.46000	.454	.393	.400	**19**	.035890	.042	.0410	.0400
000	.40964	.425	.362	.372	**20**	.031961	.035	.0350	.0360
00	.36480	.380	.331	.348	**21**	.028462	.032	.0320	.0320
0	.32486	.340	.307	.324	**22**	.025347	.028	.0280	.0280
1	.28930	.300	.283	.300	**23**	.022571	.025	.0250	.0240
2	.25763	.284	.263	.276	**24**	.020100	.022	.0230	.0220
3	.22942	.259	.244	.252	**25**	.017900	.020	.0200	.0200
4	.20431	.238	.225	.232	**26**	.015940	.018	.0180	.0180
5	.18194	.220	.207	.212	**27**	.014195	.016	.0170	.0164
6	.16202	.203	.192	.192	**28**	.012641	.014	.0160	.0148
7	.14428	.180	.177	.176	**29**	.011257	.013	.0150	.0136
8	.12849	.165	.162	.160	**30**	.010025	.012	.0140	.0124
9	.11443	.148	.148	.144	**31**	.008928	.010	.0130	.0116
10	.10189	.134	.135	.128	**32**	.007950	.009	.0120	.0108
11	.090742	.120	.120	.116	**33**	.007080	.008	.0110	.0100
12	.080808	.109	.105	.104	**34**	.006305	.007	.0100	.0092
13	.071961	.095	.0920	.0920	**35**	.005615	.005	.0095	.0084
14	.064084	.083	.0800	.0800	**36**	.005000	.004	.0090	.0076
15	.057068	.072	.0720	.0720	**37**	.004453		.0085	.0068
16	.050820	.065	.0630	.0640	**38**	.003965		.0080	.0066
17	.045257	.058	.0540	.0560	**39**	.003531		.0075	.0052
18	.040303	.049	.0470	.0480	**40**	.003145		.0070	.0048

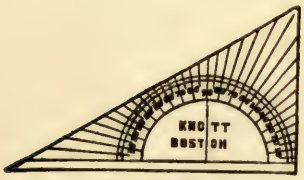
SQUARES AND PROTRACTORS
SLIDE RULES



No. 13–10

13–10 WALTER SMITH SCHOOL SQUARE. This instrument, simple in design, neat in appearance, and universal in its varied applications as rule, square, and protractor, has from its popularity of 35 years' unquestioned utility become a standard laboratory instrument.

	a	b	c
Length, inches .	7	8	10
Each	$0.07	$0.10	$0.12



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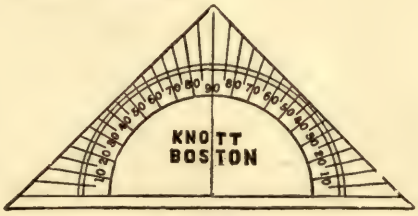
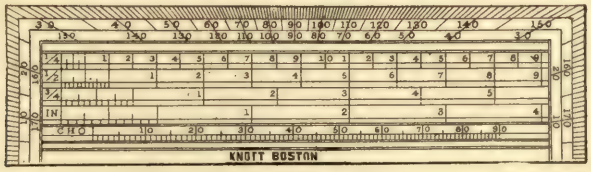


No. 13–22



No. 13–30

13–20 PROTRACTOR TRIANGLE, Transparent, 30 and 60 degree angles, long leg 5 inches, divided to 1 degree $0.60

13–22 PROTRACTOR TRIANGLE, same as above, but 45 degree angles 75

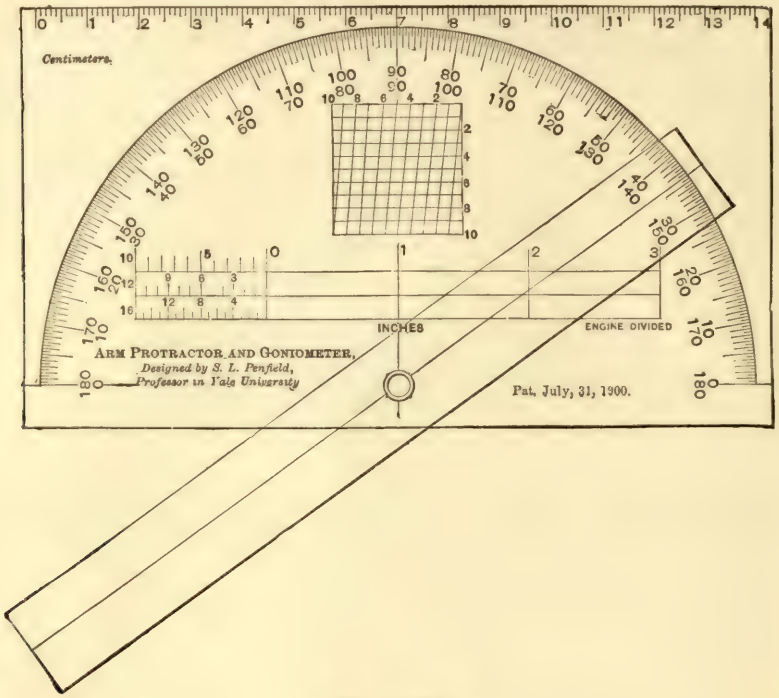
13–30 SQUARE PROTRACTOR, Ivory, 6 × 1¾ inches, graduations to single degrees, scales of ¼, ½, ¾, and 1 inch to the foot, scale of chords, and diagonal scale 2.10

13–35 SQUARE PROTRACTOR, Boxwood, otherwise same as No. **13–30** 45

No. 13–50

13–50 COMBINATION BEVELED PROTRACTOR, RULE, and **SQUARE,** protractor engine-divided to 90 degrees, care being taken to insure that the zero is accurately at right angles to the face of the head. An accurately graduated, hardened, 12-inch adjustable rule passes through the revolving turret and may be clamped at any point by means of the thumb nut. A small level attached to one side of the head is adjustable to show any degree.

The utility of this combination instrument is unquestioned and its purchase will never be regretted . **$3.45**



No. 13–75

13–75 THE PENFIELD ARM-PROTRACTOR AND GONIOMETER designed and patented by Prof. S. L. Penfield, late professor in Yale University, New Haven, Conn.

This instrument consists of a graduated semi-circle printed on a card, in combination with an arm of transparent celluloid, swiveled by means of an eyelet at the center of semi-circle. A fine index line, scratched on the under side on the celluloid arm parallel to its edges, indicates, by its position in reference to the graduations, the angle which the arm makes with the base line of the card. The graduated semi-circle is printed with its 0–180 degree line exactly parallel with the upper and lower edges of the card, and the eyelet is so placed that its center is in alignment both with the 0–180 degree line of the graduation and the index line of the celluloid arm.

In addition to its use as an ordinary protractor, it has the further advantage of straight edges, no rule, therefore, being necessary. It need not be adjusted to a base line and centered at some specific point. Thus, in drawing an angle, one setting of the index line gives accurate direction for the sides within three minutes of correct, the error arising, not from errors in the instrument, but in the width of the pencil line. In connection with a T-square, this protractor is admirably adapted for laying off angles quickly and accurately, taking the place of the ordinary triangles.

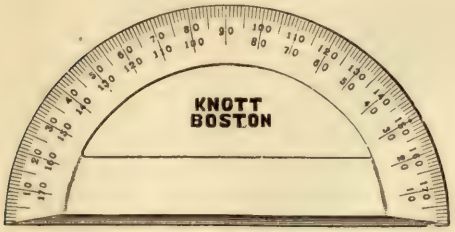
The diagonal scale within the semi-circle measures just an inch on a side, and by means of it any desired hundredths of an inch may be determined.

This instrument may also be used as an accurate Goniometer in measuring plane angles.

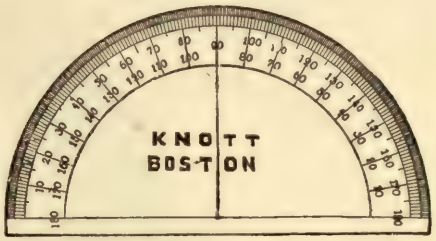
Each instrument is substantially built, all graduations engine divided, and parts accurately and carefully assembled. Enclosed in a stout manila envelope with complete directions compiled by Prof. Penfield **$0.80**

13–76 THE PENFIELD CONTACT-GONIOMETER for measuring angles of crystals. As a transparent arm is confusing when measuring angles of crystals, the instrument above may be obtained having the celluloid arm opaque for a portion of its length. Enclosed in stout manila envelope with complete directions by Prof. Penfield . . . . . **.80**

13–77 THE PENFIELD CONTACT-GONIOMETER for measuring internal angles. Enclosed in stout manila envelope with complete directions by Prof. Penfield . . . . . **.80**



No. 13–90



No. 13–100

13–90 **BRASS PROTRACTOR,** a good serviceable protractor, 3¾ inches in diameter, graduated in single degrees $0.12

13–92 **BRASS PROTRACTOR,** engine-divided, best quality, 4¼ inches in diameter, graduated in single degrees 25

13–94 **BRASS PROTRACTOR,** engine-divided, best quality, 5⅛ inches in diameter, graduated in ½ degrees .55

13–96 **GERMAN SILVER PROTRACTOR,** best quality, 4¼ inches in diameter, graduations in single degrees 48

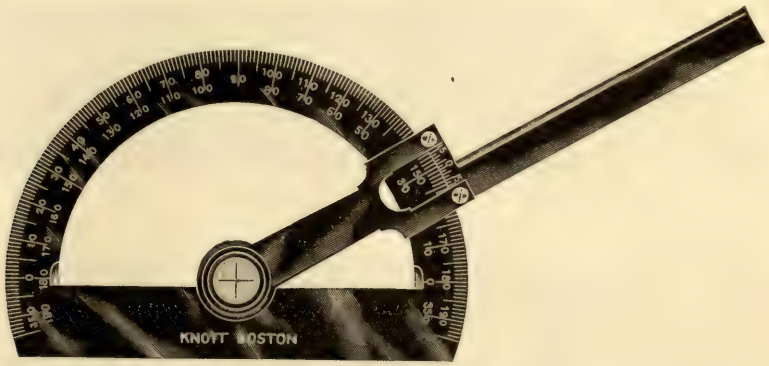
13–98 **GERMAN SILVER PROTRACTOR,** best quality, 5⅛ inches in diameter, graduations in ½ degrees . .80

13–100 **TRANSPARENT AMBER PROTRACTOR,** semi-circular, solid, graduations and figures stamped from engine-divided plate, and clearly shown in black.

	a	b	c	d
Graduations in . . .	1	½	½	½ degree.
Diameter	4	5	6	8 inches.
Each	$0.18	.40	.85	1.35

13–105 **BRISTOL BOARD PROTRACTOR,** printed from engine-divided plate, diameter 4 inches, graduated to single degrees, figures reading from each end 12

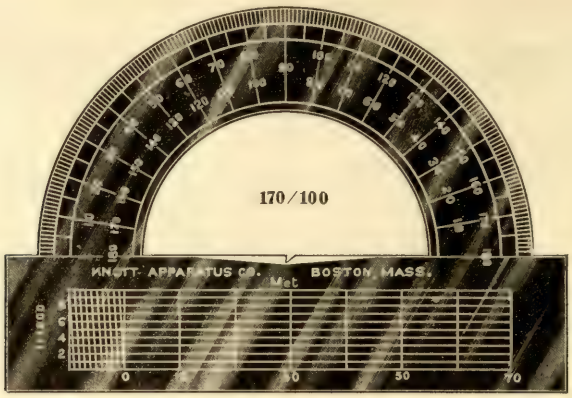
13–107 **BRISTOL BOARD PROTRACTOR,** similar to above, but 5 inches in diameter and graduated to ½ degree . . . . . Per Dozen .45



No. 13–120

13–120 **GERMAN SILVER PROTRACTOR,** engine-divided with highest possible care and accuracy, 5½ inches in diameter, graduations in ½ degrees, vernier arm reading to 3 minutes. With horn center. Duty Free $7.50

13–122 **GERMAN SILVER PROTRACTOR,** same as above, but 8 inches in diameter, graduations in ¼ degrees, vernier reading to 1 minute. Duty Free 11.25

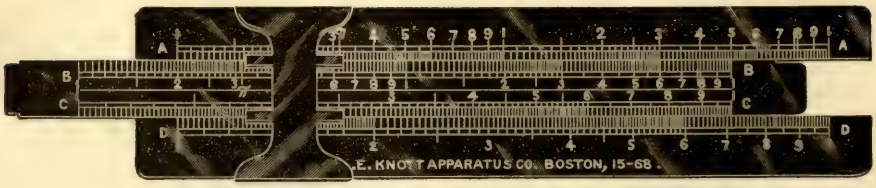


No. 13–135

13–135 COMBINATION PROTRACTOR AND DIAGONAL SCALE, brass, silver-finished, 5⅛ inches long, graduations in single degrees, figures reading both directions. Diagonal scale reading 8 centimeters by ⅒ millimeter **$0.60**

No. 13–160

13–160 METRIC DIAGONAL AND PLOTTING SCALE of boxwood, 15 centimeters long. One side, double diagonal Scale, — one ruled square of 2 centimeters width; the other square, 1 centimeter width, thus allowing measurements up to 15 centimeters by ⅒₀ millimeter with one and by ⅕₀ millimeter with the other. The reverse side is divided as a plotting scale, having reduction scales of **1:4**, **1:5**, **1:7**, **1:8**, and **1:9** **$0.10**



No. 13–175

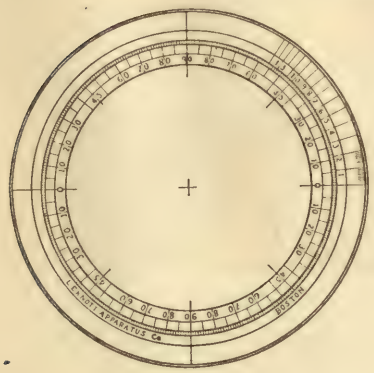
13–175 STUDENT'S SLIDE RULE, for performing arithmetical computations mechanically, — multiplication, division, squares, and square roots, ratio, etc. All are possible with accuracy to three figures. This rule is made of the best quality of hard, gloss-finish bristol board, is 5 inches long, with letters, figures and graduations neatly and distinctly shown **$0.50**

13–180 MANNHEIM'S SLIDE RULE, graduations on white paper with protective coating, transparent indicator in metal frame. 10 inches long. With simple directions **1.40**

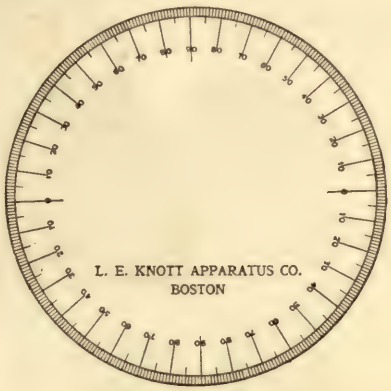
13–185 SLIDE RULE WITH MAGNIFYING LENS ATTACHMENT, highest quality imported computing rule with prominent qualities which recommend it wherever a rapid, accurate, and simple scale is desired. Besides an extreme accuracy of parts and graduation, this rule is substantially constructed of mahogany and inlaid with celluloid. Results are obtained directly, without mental effort and without computations.

	a	b	c
Length	25	36	50 centimeters.
Duty Free	**$4.35**	**$9.85**	**$14.65**

CIRCULAR PROTRACTORS, DIVIDING ENGINES, LEVELS, PLUMBS



No. 14–10



No. 14–20

14–10 WETMORE'S TANGENT SCALE. This design was suggested by the late Prof. E. W. Wetmore, Normal College, Albany, N. Y. It consists of an engine-divided bristol board dial 3¾ inches in diameter, divided from 0 to 90 degrees in each quadrant to single degrees. On an outer circle tangents of corresponding angles are indicated.

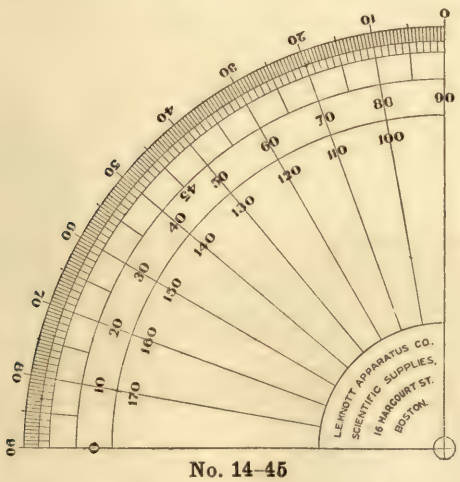
With this dial the tangents of deflection may be noted directly instead of angles themselves, thus current strength may be compared directly without reference to any table . . . . . Each **$0.08**

14–15 BRISTOL BOARD CIRCULAR PROTRACTOR, 13 inches in diameter, with radial lines every 10 degrees and further subdivided on two outer circles to single and to ¼ degrees.

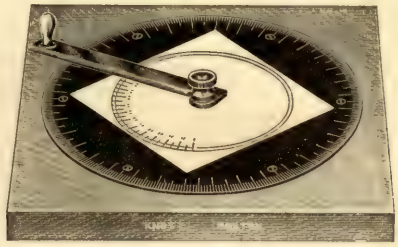
This protractor may be used to advantage in experiments on composition of forces or on torsion . Each **.50**

14–20 BRISTOL BOARD CIRCULAR PROTRACTOR, 4 inches in diameter. Graduated in single degrees. Each **.12**

14–25 BRISTOL BOARD CIRCULAR PROTRACTOR, 3 inches in diameter. Graduated to two degrees Each **.10**



No. 14–45



No. 14–60

14–45 BRISTOL BOARD QUARTER-CIRCLE PROTRACTOR, a full quadrant of circle 13 inches in diameter, radial lines every 10 degrees, graduated to single and ½ degrees, figured from 0 to 90 degrees in both directions.

This protractor is used in experiments in torsion **$0.16**

14–60 ANGLE-GRAPH for plotting any angle from 0 to 360 degrees, excellent for plotting protractors.

This instrument consists of a neatly-finished wooden base on which is mounted a brass ring, the upper surface of which is accurately engraved from 0 to 360 degrees. At the geometric center of this circle is fastened a brass rod with projecting screw at its center. An index and sketching arm are held movably about this screw by means of a friction thumb nut.

In use, the card or paper which is to be divided is placed with its central hole over the rod in the central part of the apparatus. By moving the index arm any angle from 0 to 360 degrees may be plotted. Illustration shows the method of making a circular protractor.

As the instrument will take in any size up to 13 inches diameter, it will be found of great convenience in any laboratory **6.15**

For **DIVIDING ENGINES,** see Index.

No. 14–90

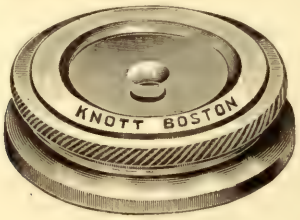
14–90 **CARPENTERS' STANDARD LEVEL,** first quality, of polished cherry with brass arch top-plate and side views. 12 inches long **$0.75**

No. 14–95

No. 14–100

14–95 **WOOD POCKET LEVEL,** first quality, brass top, 5 inches long **$0.40**

14–100 **LEVEL,** extra quality, solid rosewood, brass corners, top-plate and end, brass side views. Length 6½ inches **1.50**



No. 14–110

No. 14–115

14–110 **BALANCE LEVEL,** as used on balances and cameras. Will indicate in all directions **$1.00**

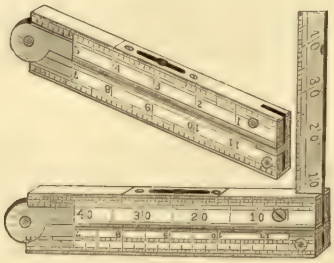
14–115 **TWO-WAY LEVEL AND PLUMB,** valuable in plumbing, squaring, and leveling up work. Leveling is indicated in every way without moving the tool.
Weighs 3 ounces, measures 2 × 3 × ¼ inch thick **1.75**

No. 14–125

14–125 **MERCURY PLUMB BOB,** made from solid steel bored and filled with mercury. Improved by patented slot device for fastening string without tying, also by simple effective device at top for fastening end of string after winding up.
Each bob is nickel plated and provided with braided silk line. Weight 6 ounces, length 5 inches, diameter ⅝ inch **$1.65**

14–130 **PLUMB BOB,** iron, black japan finish . . . . . **.12**

No. 14–130

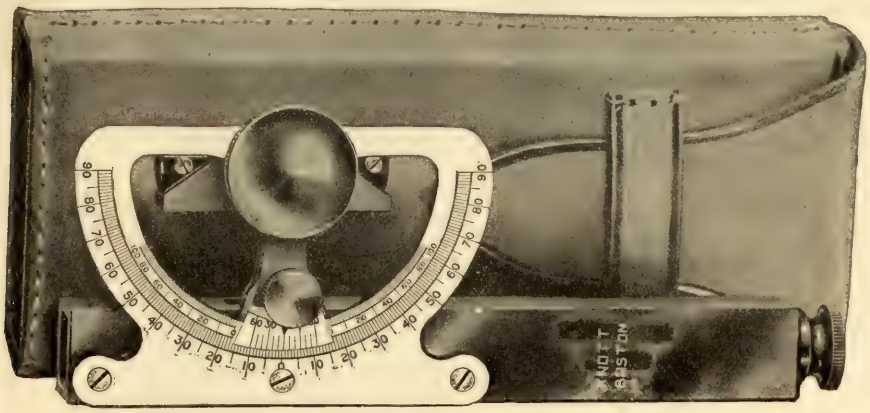


No. 14–135

14–135 **TWO-FOLD COMBINATION RULE,** comprising in itself a Carpenter's Rule, Spirit Level, Try Square, Plumb, Slope Level, Brace Scale, Draughting Scale, T-Square, Protractor, Right Angled Triangle, and, with a straight edge, a Parallel Rule.
Illustration shows use as a Level and as a Try Square, the upper cut showing steel blade folded like a knife blade into part which holds it.
Made of boxwood, hand-polished finish, well protected with heavy brass binding. Folded, measures 6 × 1⅜ × ⅜ inches **$2.25**

No. 14–140

14–140 POCKET REFLECTING LEVEL, in bronze metal case, 5 inches long. In leather case complete . . **$5.25**

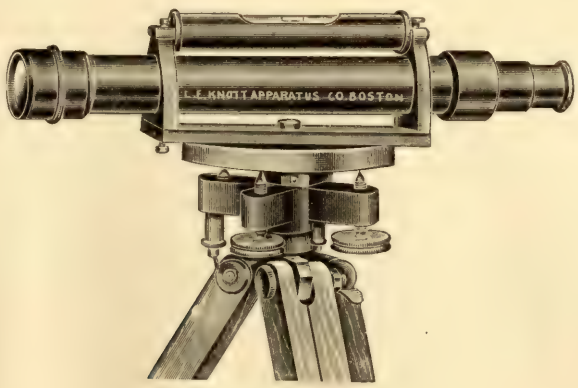


No. 14-145

14–145 ABNEY'S POCKET ALTIMETER, REFLECTING LEVEL OR CLINOMETER, for slope and height determination. Useful for determining rise and fall for drainage purpose, slope for railroads, etc., determining heights of various objects such as trees, hills, etc.

This is the improved level with large German Silver arc with draw telescope, silver reflector, and positive clamping device for vernier. Enclosed in leather case . . . . . Duty Free **$10.75**

14–147 ABNEY'S POCKET ALTIMETER, same as No. **14–145,** with the further improvement of an attached compass . . . . . Duty Free **14.25**



No. 14–155

14–155 DRAINAGE OR AGRICULTURAL LEVEL. Telescope with object glass $13/16$ inch diameter and 8 inches focal length, with metal protecting cap and sliding focusing adjustment. This Level is further supplied with convenient arrangement for horizontal leveling, — leveling head with four screws and graduated bubble.

Each instrument is supplied with a substantial adjustable tripod which is enclosed with instrument, screw driver, and adjusting pin, in polished wooden box . . . . . Duty Free **$28.00**

BALANCES AND WEIGHTS

The selection of proper laboratory balances together with appropriate sets of weights for any given laboratory is perhaps one of the most difficult tasks which an instructor is called upon to perform. In the hope that it will be of assistance, we have arranged in tabular form our very complete line of Balances and Weights, dividing them into three arbitrary groups. We believe that if the instructor will consider carefully the kind of work which is to be performed and will then consult the tables, he will be able to determine which balances or combination of balances will secure the best results.

Every laboratory, to be well equipped, should have at least one sensitive Analytical or Assay Balance. Balances of this sort, with the weights to go with them, will be found in Group One. In Group Two, we have included balances of medium grade, that is, — balances of reasonable precision where the utmost accuracy and sensitiveness is not required. Group Three contains miscellaneous balances for heavy and general laboratory work.

In considering the classification given below, it should be borne in mind that it is impossible to draw a hard and fast dividing line between each of the three groups. In making the classification however, we have been guided by our years' experience in work of this kind, and we have taken the risk of making the experiment in the hope that the tables will be of assistance to teachers who are not familiar with the capacities and sensibilities of the best balances for general scientific work. Detailed descriptions and illustrations will be found on the following pages under the numbers specified in the tables below.

ASSAY AND ANALYTICAL BALANCES

Number	Sensibility
15–10	1/100 mg.
15–15	1/50 mg.
15–20	1/20 mg.
15–25	1/5 mg.
15–27	1/10 mg.
15–30	1/10 mg.
15–35	1/10 mg.
15–40	1/10 mg.

WEIGHTS for above Balances

Nos. 16–10 to 16–125

SCHOOL BALANCES

Number	Sensibility
15–45	1/5 mg.
15–50	1/2 mg.
15–55	1/2 mg.
15–70	1 cg.
15–75	3 cg.
15–80	1 cg.

WEIGHTS for above Balances

Nos. 16–10 to 16–125 and Nos. 16–150 to 16–180

GENERAL LABORATORY BALANCES

Number	Sensibility	Number	Sensibility
15–100	1/2 cg.	**15–130**	
15–105	1/2 cg.	**15–135**	
15–110	100 mg.	**15–140**	1 cg.
15–115	1 mg.	**15–150**	1 oz.
15–120	5 mg.	**15–160**	1/2 cg.
15–125	5 mg.	**15–165**	1 cg.

HAND BALANCES

Nos. 15–200 to 15–225
No. 15–250 Jolly Balance

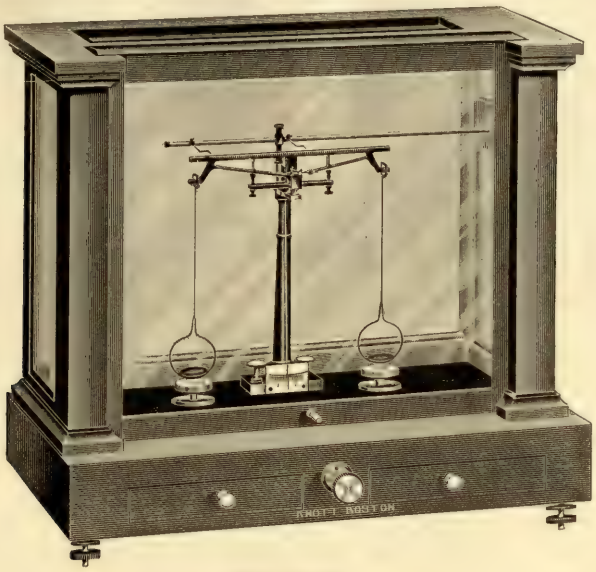
SPRING BALANCES

Nos. 15–300 to 15–375

WEIGHTS for above Balances
Nos. 16–300 to 16–385

IRON WEIGHTS
Nos. 16–425 to 16–478

BALANCES, ASSAY AND ANALYTICAL



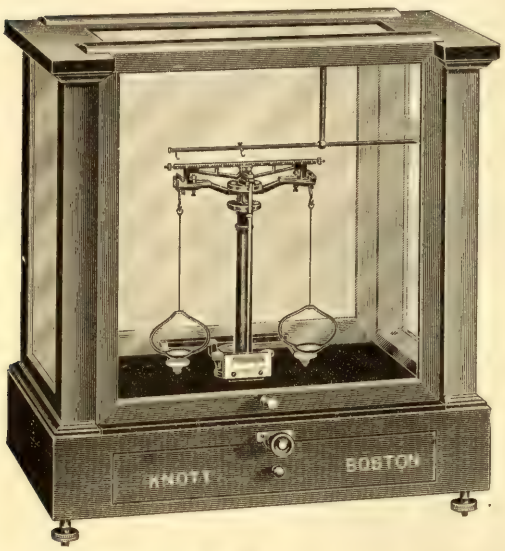
No. 15–10

15–10 HIGH-GRADE ASSAY BALANCE, sensibility $\frac{1}{100}$ milligram, agate edges and planes, enclosed in case.

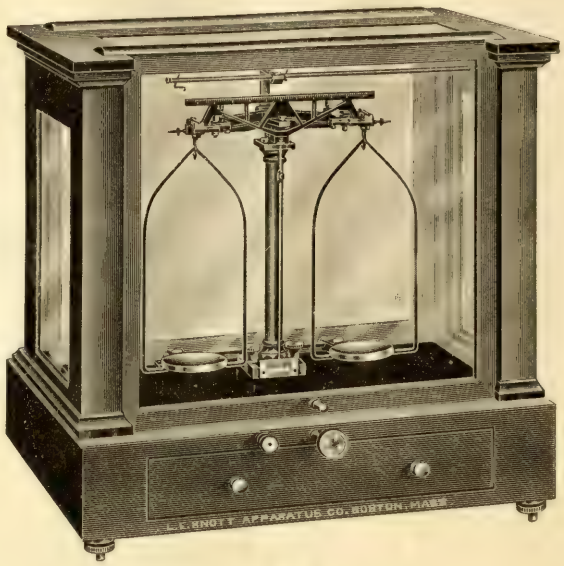
Beam 19 centimeters long, open construction, made of aluminum alloy possessing a high tensile strength and a uniform density, divided into $\frac{1}{100}$ milligram divisions showing white on black oxidized beam. Edges and Planes are accurately ground from the highest quality stones. Provided with simple Beam Hoist and Pan Arrest. Rider Carriage is operative over full length of beam. Hangers, of usual skeleton type, are made of nickel silver, Pans of aluminum.

Balance is mounted on Double-Drawer Base topped by Black Glass Slab and provided with Leveling Screws. It is enclosed in Polished Mahogany Case with glass front slide, glass sides and top. All parts are handsomely finished with a durable acid-resisting transparent lacquer.

Price from stock, **$110.00**



No. 15–15



No. 15–20

15–15 KNOTT'S HIGH-GRADE SHORT BEAM ASSAY BALANCE, sensibility $\frac{1}{5}\frac{1}{0}$ milligram, agate planes and edges, enclosed in case.

Beam, 12.5 centimeters long, open construction, is divided to $\frac{1}{5}\frac{1}{0}$ milligram the full length from 0 at the central knife edge. Beam Lift and Pan Arrest operate simultaneously by knurled head to be noted in illustration. Planes and Edges are carefully ground from selected agate of the highest quality. Rider Carriage of simple double-hook type operates from right of case.

The balance is handsomely finished throughout and covered with a colorless protective lacquer. It is mounted on black, heavy Plate-glass Base with Drawer Sub-base and enclosed in highly polished Mahogany Case with front and back slides, glass sides and top.

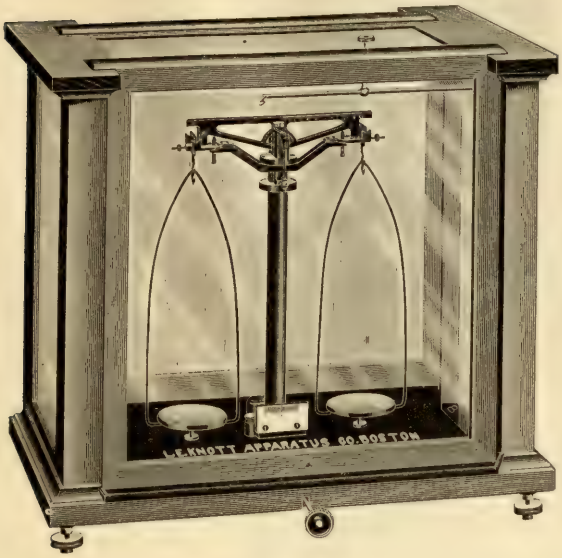
Duty Free, **$94.50**

15–20 KNOTT'S HIGH-GRADE ANALYTICAL BALANCE, capacity 200 grams, sensibility $\frac{1}{2}\frac{1}{0}$ milligram, agate edges and planes, enclosed in case.

Beam 18 centimeters long, open truss construction, made of aluminum alloy possessing a high tensile strength and a uniform density, is divided into $\frac{1}{2}\frac{1}{0}$ milligram divisions filled white on the black oxidized beam. Edges and planes are ground from carefully selected agate of highest quality. Provided with independently operative Beam Hoist and Pan Arrests, the pan arrests being of special design easily controlled and if desired self locking. Rider carriage of simple double-hook pattern has full clear sweep over entire length of beam. Pans and Bows are of nickel silver, the pans being about 5.5 centimeters in diameter.

Balance is mounted on Drawer Base topped by heavy Black Glass Slab provided with sensitive crossed vial Level and Leveling Screws. It is enclosed in Polished French Mahogany Case with front and back slides, glass sides and top. It is handsomely and durably finished with an acid-resisting colorless lacquer.

Price from stock, **$117.50**



No. 15–25

No. 15–30

15–25 THE "BERLIN" SHORT ARM ANALYTICAL BALANCE, capacity 200 grams, sensibility $\frac{1}{5}$ milligram, agate edges and planes, enclosed in case.

Beam, 15 centimeters long, open construction, is divided into $\frac{1}{5}$ milligram. Simple Rider Carriage operates over half of beam. Agate Edges and Planes carefully ground from selected stones. New, effective Pan and Beam Arrestment operative simultaneously. Bows and Pans made of nickel, pan 5 centimeters in diameter being attached.

Balance is mounted on Black Glass Slab provided with quick-acting Circular Level and Leveling Screws. It is enclosed in Polished Mahogany Case with glass front and back slides, glass sides and top. It is finished with a protective acid-resisting lacquer.

This balance meets all requirements for accurate and rapid weighings.

Duty Free, **$42.50**

15–27 THE "BERLIN SECOND" SHORT ARM ANALYTICAL BALANCE same as No. **15–25** but sensitive to $\frac{1}{10}$ milligram.

Duty Free, **$48.25**

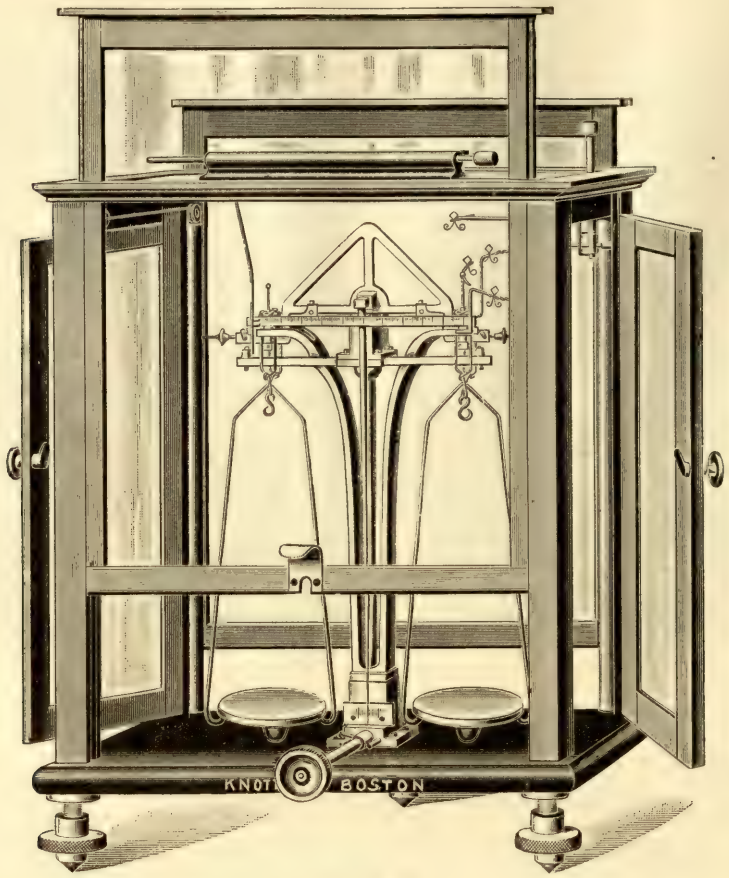
15–30 HIGH-GRADE ANALYTICAL BALANCE, capacity 100 grams, sensibility $\frac{1}{10}$ milligram, agate edges and planes, enclosed in case.

Beam, 15 centimeters long, open construction, made of aluminum alloy possessing high tensile strength and uniform density, is divided the full length from 0 at center into $\frac{1}{10}$ milligram. Edges and Planes carefully ground from the highest quality selected agate. Independently operative Beam Hoist and Pan Arrest. Simple, single hook Rider Adjustment has full, clear sweep of entire length of beam. Pans and Bows are of nickel, pans, 7.5 centimeters diameter being attached to bows.

Balance is mounted on Drawer Base provided with quick-acting Circular Level and Leveling Screws. It is enclosed in Polished Mahogany Case with front and back glass slides, glass sides and top. It is Heavily Platinum Plated throughout, thus insuring against corrosion.

This is pre-eminently an analytical balance. Its accuracy, and its effective adjustments insure results.

Price from stock, **$56.00**



No. 15–35

15–35 ANALYTICAL BALANCE, AMERICAN MODEL, capacity 200 grams, sensibility $\frac{1}{10}$ milligram, agate planes and edges, enclosed in case.

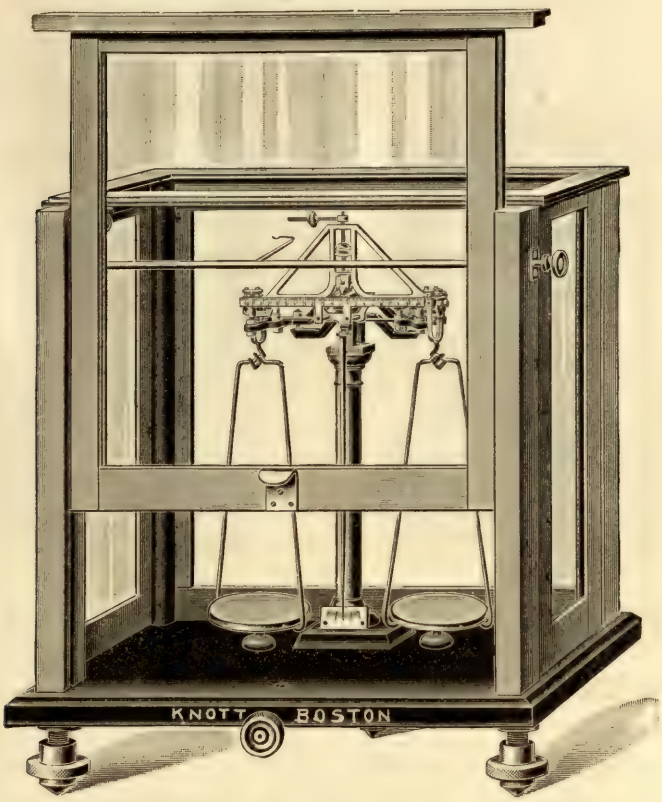
Beam, 15 centimeters long, open triangular construction of aluminum, graduated to $\frac{1}{10}$ milligrams the entire length from 0 at the left. Rider, attached movably on scale is efficiently and easily operated by Rider Carriage worked from the right. Pans attached to stirrups, are 8 centimeters in diameter. Edges and Planes are carefully ground and adjusted from selected agate of highest quality. Pan Arrests are of simple brush type; Beam Hoist operates upon beam with minimum jar.

A feature of this balance is the Secondary Rider Apparatus to be noted in illustration at right near the top. It consists of two-part Rider Rest firmly attached to right side of balance case and to balance arm. Secondary Rider Support consists of small, short upright with horizontal extensions, which is attached on right hanger. Rider Carriage is operated from top. In use the Riders, which total one gram, are placed in position on Rider Rest; they may be added or removed from Rider Support by means of the Rider Carriage without opening case. By means therefore of simple Rider and this secondary Rider Apparatus a weight up to 1.01 grams may be added without opening the case.

Balance is mounted on heavy Black Glass Base provided with Cross Circular Spirit Level and leveling screws. It is enclosed in highly polished mahogany case with glass front and rear slides, glass side-doors, and glass top. It is handsomely finished in gold and nickel with a protective coating.

For quantitative work this balance will be found excellent in every way and we confidently recommend its purchase to all to whom its features of accuracy and utility appeal.

Duty Free, **$73.75**



No. 15-40

15-40 "MODEL AMERICA" ANALYTICAL BALANCE, capacity 200 grams, sensibility $\frac{1}{10}$ milligram, agate planes and edges, enclosed in case.

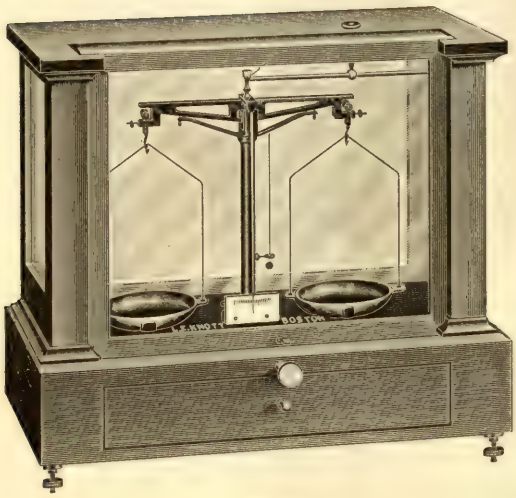
Beam, 15 centimeters long, open triangular construction of magnalium metal, graduated to $\frac{1}{10}$ milligram on either side of 0 over central knife edge. Compensating Hangers are made in one piece and being suspended on three points allow for uneven balancing. Planes and edges are ground from carefully selected agate of best quality. Arrest, worked by knurled screw noted in illustration, operates simultaneously upon beam, hangers, and pans.

Balance is mounted on heavy Black Glass Base provided with plumb bob and leveling screws. It is enclosed in a highly-polished Mahogany Case with glass front slide, glass sides, top and back.

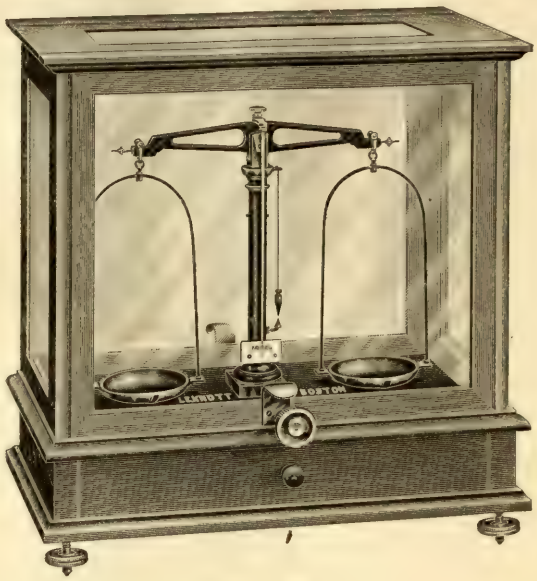
This balance has won a wide, justly-deserved reputation among chemists and will be a balance of high quality.

Duty Free, **$38.50**

SCHOOL BALANCES



No. 15–45



No. 15–50

15–45 "HARCOURT SPECIAL" QUICK-ACTING BALANCE, capacity 100 grams, sensibility $\frac{1}{5}$ milligram, agate edges and planes, enclosed in case.

Beam, 18 centimeters long, open construction, is divided into $\frac{1}{5}$ milligrams on one side of central knife edge. Agate Edges and Planes carefully ground from selected stones. Simple Beam Hoist and Rider adjustment. Pans, 8.5 centimeters in diameter, are detachable.

Balance is mounted on Drawer Base, provided with Plumb Bob and Leveling Screws. It is enclosed in Polished Mahogany Case with glass front slide, glass sides, top and back.

This balance was designed especially for us and we have no hesitancy in commending it as combining all the essential qualifications of a high-grade balance at a cost within the range of any educational institution.

Price from Stock, **$39.50.** Duty Free, **$28.75**

15–50 KNOTT'S NORMAL BALANCE, capacity 100 grams, sensibility $\frac{1}{2}$ milligram, agate edges and planes, enclosed in case.

Beam, 21 centimeters long, open construction. Edges and Planes of carefully-ground agate. Simple, effectively operating Beam Hoist, detachable 8 centimeter pans.

Balance is mounted on Drawer Base, provided with Plumb Bob and Leveling Screws. It is enclosed in Polished Mahogany Case with front and back glass slides, glass sides and top.

The balance is lacquered throughout and being made especially for us by a noted manufacturer we unhesitatingly recommend its qualities.

Price from Stock, **$35.00.** Duty Free, **$25.00**

No. 15–55

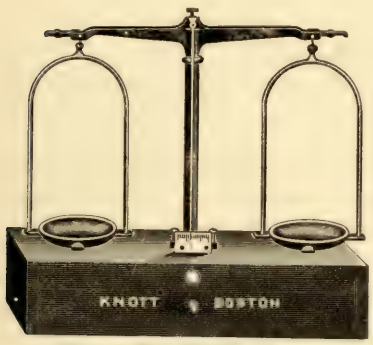
15–55 HARCOURT SCHOOL BALANCE, capacity 50 grams, sensibility ½ milligram, steel edges and planes, enclosed in case.

Beam, 20.5 centimeters long, closed construction. Edges and Planes of steel accurately ground and polished. Simple Beam Hoist. Detachable 6.5 centimeter Pans.

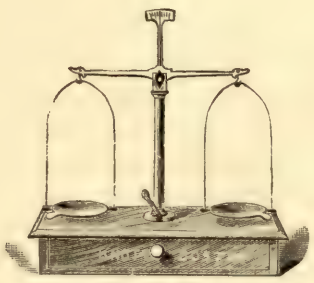
Balance is mounted on Drawer Base, provided with Plumb Bob and Leveling Screws. It is enclosed in Polished Mahogany Case, with glass front slide, glass sides, and back, lacquered throughout.

This balance is well made throughout and is dependable in all of its qualifications.

Price from Stock, **$27.50.** Duty Free, **$19.00**



No. 15–70



No. 15–80

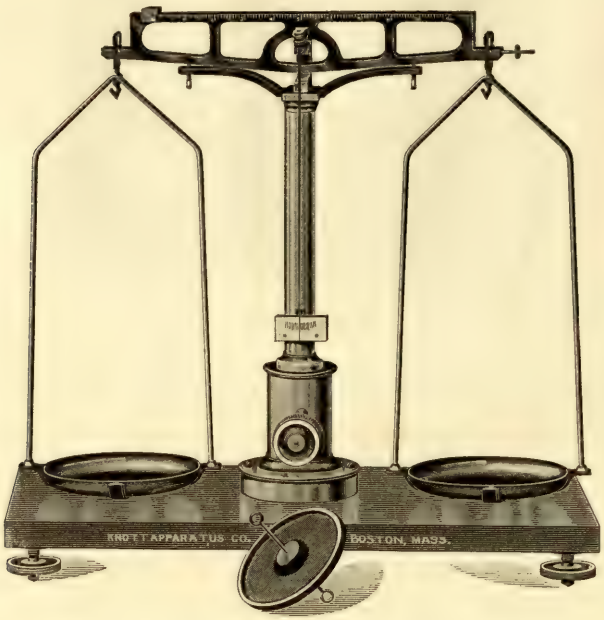
15–70 EQUAL ARM BALANCE, capacity 20 grams, sensibility 1 centigram, polished steel edges and planes, mounted on drawer base.

Beam, 23 centimeters long, closed construction with adjusting screws, is provided with eccentric lift. Pans, 7.5 centimeters diameter. Balance is mounted on Polished Mahogany Drawer Base, is polished throughout, with lacquer and nickel-plate finish **$10.00**

15–75 EQUAL ARM BALANCE, similar in design to No. **15–70,** but smaller and less sensitive. Beam 15 centimeters long, pans 6 centimeters in diameter, sensibility 3 centigrams **7.50**

15–80 EQUAL ARM BALANCE, reliable for small weighings. Beam 15 centimeters long. Pans 7.5 centimeters in diameter, Lever Lift. Balance is nickel plated throughout and is mounted on Polished Oak Drawer Base **3.00**

PHYSICAL LABORATORY BALANCES



No. 15-100

15-100 "THE BOSTON" LABORATORY BALANCE, capacity 2000 grams, sensibility ½ centigram, polished-steel knife-edges and planes, mounted on polished mahogany base provided with leveling screws.

Beam, 32 centimeters between knife-edges, of open truss construction, is divided entire length, with 0 at the left. Rider of improved design is attached movably to beam. Edges and planes are of polished steel accurately adjusted. Pans, 14 centimeters in diameter, are detachable from stirrups. Beam hoist of simple eccentric type, operated by knurled head.

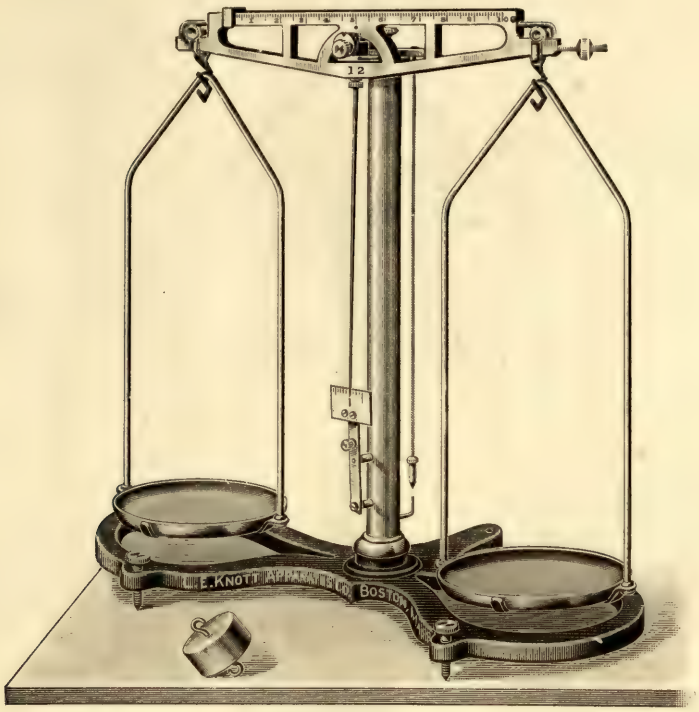
This balance is mounted on highly Polished Mahogany Base provided with Leveling Screws. It is handsomely finished and coated with protective lacquer. Pans are nickel plated.

Each balance is provided with accurate counterpoise to take place of one of the stirrups when balance is used in hydrostatic work.

Prospective purchasers of a balance of this type will do well to investigate our make before deciding on another. Our confidence in our product is such that we will gladly offer every facility for comparative tests on

1. Beam stability and uniform density.
2. Careful mechanical construction and, therefore, accuracy and sensibility.
3. Design.
4. Finish.

Duty Free, **$18.75**



No. 15–105

15-105 THE "BAY STATE" LABORATORY BALANCE, capacity 2000 grams, sensibility ½ centigram; polished steel knife edges and planes, mounted on substantial metal base.

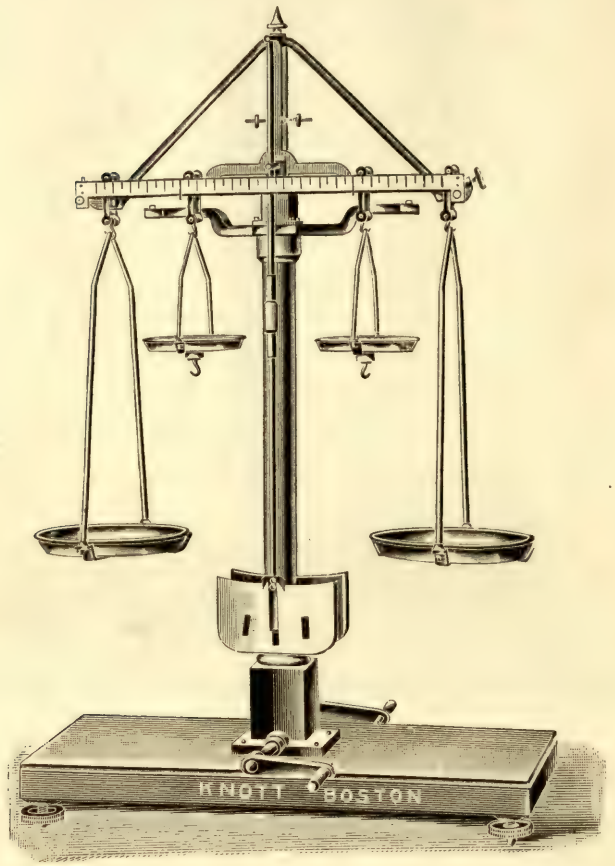
Beam, 32 centimeters between knife edges, of open truss construction, is divided the entire length from 0 at the left. Improved rider is attached movably on beam but cannot be detached. Edges and planes are of polished steel. Pans, 14 centimeters in diameter, are detachable from stirrups.

The support for this balance consists of a neatly-japanned metal base to which is mounted a nickel-plated upright which carries the beam. This upright is provided with a damper, which, operated by a thumb screw, dampens the vibrations that rapid readings may be taken. A plumb bob fastened to the upright, and leveling screws on the base, afford ample adjustments for leveling.

Each balance is furnished with an accurately balanced counterpoise to take place of one of the stirrups when it is desired to use this balance in work on hydrostatics.

Price from Stock, **$14.35.** Duty Free, **$10.80**

HYDROSTATIC BALANCES



No. 15–110

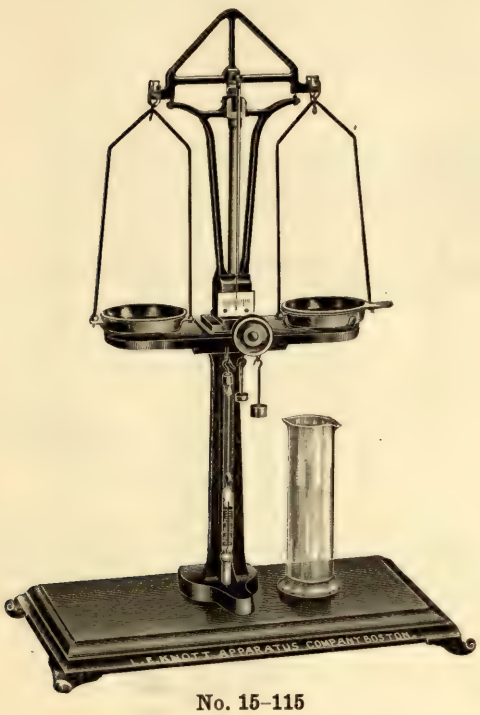
15-110 DEMONSTRATION DESK BALANCE, capacity 5000 grams, sensibility 100 milligrams, prismatic steel edges and steel planes, mounted on hardwood base.

This balance, illustrated about $\frac{1}{10}$ natural size, is of excellent size for demonstrative work in the lecture room and its sensibility allows ample scope for a large class of experiments. It is provided with all practical balance adjustments. Beam has two pairs of knife edges and planes, carefully ground and polished, the outer pair being accurately 48 centimeters, the inner 24 centimeters apart. Two pairs of scale pans, one about 23 and the other about 16 centimeters in diameter are suspended on hangers, accurately adjusted. Beam is graduated entire length from 0 at central knife-edge. Two pointers are provided for observation by both lecturer and audience.

In addition to use as balance of large capacity this balance may be used as a lever of the first class in deriving laws of lever with equal arms and with arm ratio as 1 to 2; it illustrates weighings with long and short pointer, effects of transposing point of gravity and weighing with the rider scale. As a hydrostatic balance for all demonstrative specific gravity work it is excellent.

This balance is handsomely finished in japan and nickel plated. It is mounted on substantial hardwood base provided with level and leveling screws.

Duty Free, **$54.00**



No. 15–115

No. 15–120

15–115 SPECIFIC GRAVITY BALANCE, capacity 200 grams, sensibility 1 milligram, polished steel edges and planes.

Beam, 14 centimeters long, open triangular construction, is made of aluminum alloy. Planes and edges are of steel, accurately ground and polished. Beam lift, of simple construction, easily operated. Detachable pans 7 centimeters in diameter, with removable *papier maché* pan linings.

Balance is mounted on neatly japanned, substantial cast-iron support, upright of which is of sufficient height to allow clear space for experimentation in specific gravity determinations. Each balance is supplied with a Thermometer Plummet (Reimann's patent), two counterpoises of 10 and 5 gram weight, and with a glass hydrometer jar.

This balance will be found excellent for exact results in specific gravity determinations of solids and liquids and for comparing weights up to 200 grams with the standards. It may readily be used also for finer weighings.

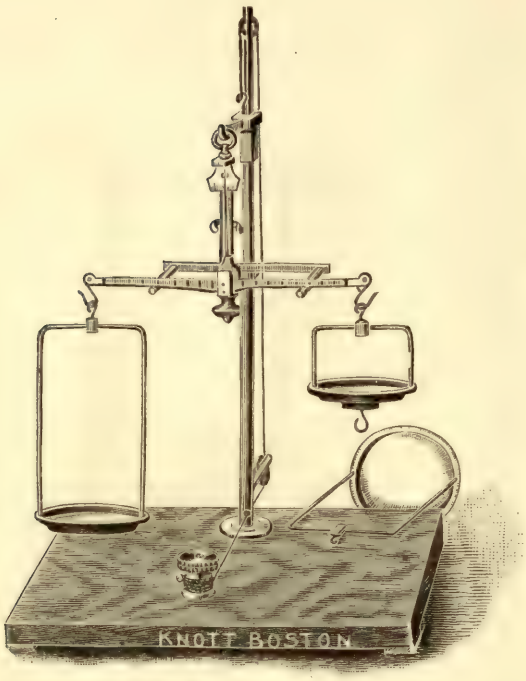
Duty Free, **$19.25**

15–120 WESTPHAL'S SPECIFIC GRAVITY BALANCE for rapid determinations of specific gravity of liquids up to fourth place of decimals.

Beam, one-arm type, is adjustable in pillar. Pillar shown attached to top of box may be readily detached and packed away in the box. All parts are carefully finished and lacquered, box highly polished mahogany.

Each balance is furnished with an accurate thermometer (Reimann's patent), counterpoise, jar, and eight riders.

Price from Stock, **$14.00.** Duty Free, **$9.80**



No. 15–125

No. 15–130

15–125 KNOTT'S HYDROSTATIC BALANCE, ADJUSTABLY SUSPENDED BEAM, capacity 250 grams, sensibility 5 milligrams, polished steel edges and planes, mounted on polished mahogany base.

Beam 25 centimeters long, close construction, is divided the whole length with 0 at center. Beam hoist consists of pulley and capstan which has proved excellent in operation. Pans, attached to stirrups, are 7 centimeters in diameter.

In use as a hydrostatic balance, a short stirrup with attached pan is provided and used as illustrated. By means of our beam hoist, beam can be raised sufficiently to allow a clear space of 23 centimeters below specific gravity pan.

This balance is made to our order and carried in stock for us in Europe. It is accurately adjusted and neatly finished in gold lacquer and nickel plate. It is mounted on substantial, polished, hardwood base . . . . . Duty Free **$13.50**

15–130 HYDROSTATIC BALANCE, prismatic-steel knife-edges, mounted on japanned, round, iron base. Beam 8½ inches long is supported on polished-steel knife-edges on planes held in a stirrup attached to the top of a brass rod which telescopes into a brass tube. The whole is neatly mounted on japanned, round, iron base.

The two pans attached by chains to hooks near the ends of the beam are 4 inches in diameter and are heavily nickel plated. One pan is suspended by short lengths of chain and is provided with hook for experiments in specific gravity. The beam may be elevated, giving an adjustment of from 6 to 14 inches from the top of the table. This balance will be found satisfactory for experiments in specific gravity. It is of the best workmanship and handsomely finished throughout **5.75**

15–135 SPECIFIC GRAVITY BALANCE, similar in design to No. **15–130,** but smaller. Beam is 6 inches long, pans 2½ inches diameter, height of hook possible from 4½ to 10 inches **3.90**

WEIGH-BEAM BALANCES

No. 15–140

No. 15–150

15–140 TRIPLE BEAM BALANCE, for rapid and accurate weighings in Physical or Chemical Laboratory. Capacity 111 grams, sensibility (guaranteed) 1 centigram.

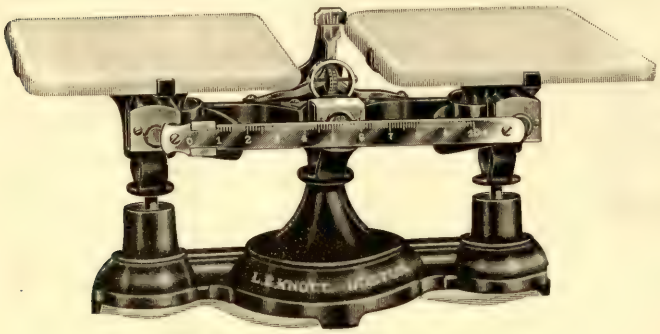
As name "Triple Beam" describes, this balance is constructed with three beams so placed one over the other as to secure uniform weight upon the knife-edge. The lower beam has a capacity of 100 grams by 10-gram divisions; the middle beam, 10 grams by single grams; the upper beam, 1 gram by $\frac{1}{10}$ and $\frac{1}{100}$ gram, each beam carrying an accurately adjusted weight attached movably to it. Base is substantially made of cast iron neatly japanned and is provided with sensitive spirit level and leveling screw. Upright, neatly nickel plated, carries an adjustable support, for the receptacle in specific gravity experiments. At top of upright there is a knurled head which operates a simple lift for beam when not is use. Pan, 10 centimeters in diameter, is detachable.

This balance is constructed of metal throughout and is neatly finished in japan and nickel plate. It is distinguished for its accuracy, its sensibility with full load (guaranteed to 1 centigram but actual constant tests show sensibility of under 5 milligrams), its rapid weighings, its design,—insuring freedom from loss or breaking of weights . . . . . Duty Free **$11.90**

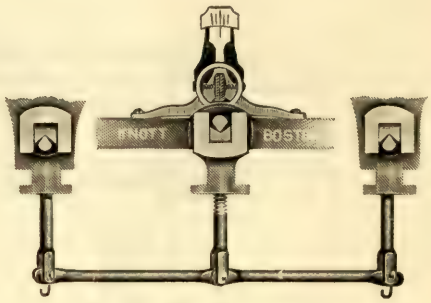
15–150 PLATFORM COUNTER SCALE for use on a counter or low platform. This scale is the standard platform scale with low pillar. A multitude of uses will be found for it in any laboratory. Capacity 200 pounds by 1 ounce. Platform measures 10½ by 14 inches.

Complete with Weights **17.50**

THE HARCOURT TRIP SCALE WITH 6″ SQUARE PLATFORM



No. 15–165



No. 15–165 Sectional View

The form of this Trip Scale is such as to make it the most convenient balance for laboratory work.

DESIGN. The center of gravity of the moving system is properly placed. Made of rigid cast metal, it will stand heavy loads without error. The knife edges are held rigidly in position and cannot change. The equal length of the arms is absolutely assured.

NEW FEATURES which have been added during the past two years are noteworthy in the field of Balance Construction:

METHOD OF READING. By reference to the cut, it will be noted that we have adopted the **straight line indicator** which eliminates all errors due to parallax.

LONG GRADUATED RIDER ARM. The length of the **rider arm** has been greatly **increased** so as to give a wide, open scale with a range of 10 grams in $\frac{1}{10}$ gram divisions.

SPECIFIC GRAVITY HOOK. For convenience in Specific Gravity Experiments, a **hook** is securely attached to **each platform post.**

ADJUSTMENT. The position of the **adjusting screw** is properly placed to avoid accidental displacement.

15–160 THE HARCOURT TRIP SCALE with 6 inch square platform with steel bearings.
This instrument combines all of the features above noted, making it without question the most serviceable laboratory Trip Scale obtainable **$5.75**

No. 15–180

15–165 AGATE-BEARING HARCOURT TRIP SCALE with 6 inch square platform.
To meet the demand for a Trip Scale with agate bearings, we are offering an instrument the same as No. **15–160** with all of the special features above noted and provided with six agate planes accurately secured and set in rigid castings.
The method of setting these planes should be noted in the detailed drawing. Its success depends upon the use of the most accurate milling device known, the agate holders being cut with such a degree of nicety and precision that we are able to guarantee the planes not to loosen or change position even to $\frac{1}{1000}$ of an inch **6.65**

15–180 THE HARCOURT INTERLOCKING TRIP SCALE SUPPORT, for use with above Trip Scales in specific gravity experiments.
In the design above illustrated, we have discarded wooden structure entirely, securing a greater stability, convenience and effectiveness of operation. The design of parts is such that danger of balance falling from support or being knocked from same is entirely obviated. The new form of base, designed so that the 6 × 8 inch battery jar or other containing vessel may be placed directly under the suspending hook, will be found a great improvement.
Complete, as illustrated, without jars or balance, but with two supporting loops **2.85**

HAND BALANCES

No. 15–200

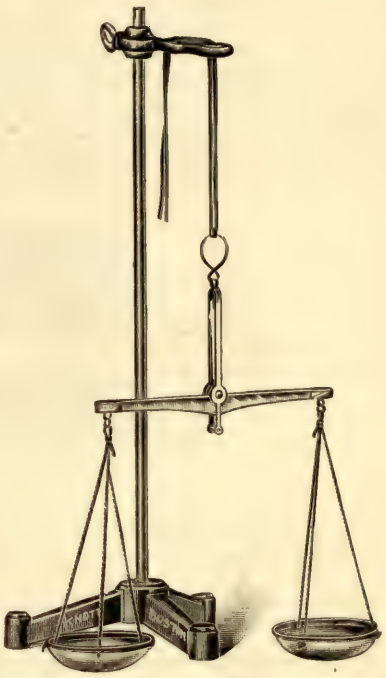
15–200 HAND BALANCE, first quality standard hand balance, 7½ inch beam; horn pans 3 inches diameter; beam, lacquered brass **$2.25**

15–205 ——, same as above, but less expensive in construction . . **1.65**

5–915 HAND BALANCE SUPPORT OR CLAMP for attaching to a tripod stand as illustrated in No. **15–225** and supporting adjustably a hand balance.

This clamp is designed for use on a 13-millimeter rod. In use, a stiff tape (a shoestring being excellent) is threaded through the ring of the hand balance and then the ends threaded through the holes in the clamp, then wrapped once about the binding screw.

Height of the balance is readily adjusted, first (coarse adjustment) by position of clamp on the rod, second (fine adjustment) by drawing tape through the holes in the clamp . . . . . **.35**



No. 15–225

15–225 HAND BALANCE AND SUPPORT. For the convenience of those who desire to order a complete balance for use with No. **5–915** clamp, we offer the outfit as illustrated, consisting of No. **5–915** clamp, tripod base with support rod, No. **15–200** hand balance with the tie **3.40**

No. 15–250

15–250 IMPROVED JOLLY BALANCE. This is a design utilizing our No. **22–130** Universal Stand used so extensively in Topic II. To this stand are clamped special clamp castings; one to hold the stirrup to which the spring is attached; another (No. **5–895**) for clamping the mirror scale; another (Platform No. **5–527**) for supporting the glass vessel. The adjustments possible with this structure and the ready adaptability of the various parts to other uses will be noted.

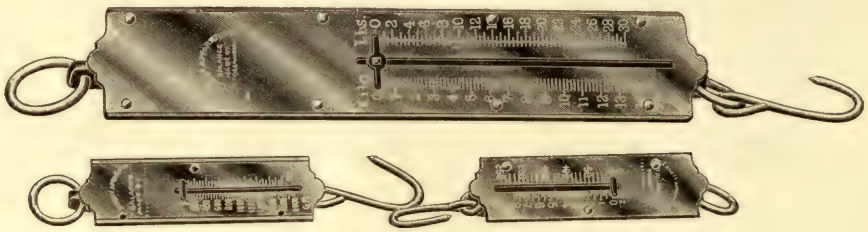
Jolly Balance complete as illustrated, with two aluminum scale pans, plummet, two springs,—one for high and one for low tension, and accessories noted above, except glass vessel **$7.85**

15–251 JOLLY BALANCE SPRING for low tension . . . . . **.90**

15–252 JOLLY BALANCE SPRING for high tension . . . . . **.90**

SPRING BALANCES

Our spring balances are constructed for us according to our specifications and for this reason our line is unique. One of our specifications in our orders to the manufacturer is that the tension of the spring must be uniformly accurate. Graduations are distinct and all parts are carefully made throughout. Handsomely finished in nickel and black oxidized finish. All our balances have double pointer for accurate readings in both horizontal and vertical positions. In use in vertical position the weight of the hook is deducted by the width of the pointer.



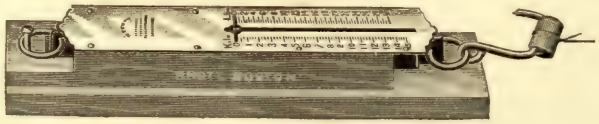
Nos. 15–300 to 15–315

15–300 **SPRING BALANCE,** double scale, 250 grams by 10-gram divisions, and 8 ounces by ¼-ounce divisions. Flat back **$0.80**

15–305 **SPRING BALANCE,** double scale, 500 grams by 20-gram divisions, and 16 ounces by ½-ounce divisions. Flat back **1.00**

15–310 **SPRING BALANCE,** double scale, 2000 grams by 25-gram divisions, and 64 ounces by ½-ounce divisions. Flat back . . . . . **.45**

15–315 **SPRING BALANCE,** double scale, 15 kilograms by 200-gram divisions and 30 pounds by ¼-pound divisions **1.65**



No. 15–365

15–360 **SPRING BALANCE CRADLE,** for holding a spring balance in a flat position. Made entirely of metal for a double-scale balance reading 250 grams and 8 ounces **$0.15**

15–365 **SPRING BALANCE CRADLE,** same as above, but made entirely of wood for a spring balance reading 15 kilograms and 30 pounds . . . . . **.45**

No. 15–375

15–375 **RINTOUL'S SPRING DYNAMOMETER,** open movement, an effectively working spring balance. Consists of the usual form spring resting in a groove, with hook for attaching to scale pan, etc. A double indicator allows reading from scale from 1 gram up to 250 grams, or from ¼ ounce up to 8 ounces, with balance in either horizontal or vertical position. An adjustment at top by which the spring can be reset allows for variations in the zero reading, providing spring should become permanently elongated. Made wholly of metal and handsomely finished in bright nickel and japan **$2.50**

WEIGHTS

STANDARD NORMAL WEIGHTS

The weights under this heading are adjusted, with the utmost nicety attainable, to the standard which has been verified by the "Bureau International des Poids et Mesures" at 0° in vacuo, to an accuracy of 0.01 milligram.

No. 16–10

16–10 STANDARD NORMAL KILOGRAM, constructed of the hardest attainable drawn-brass wire turned to shape, and trimmed by long and tedious work to practical accuracy, the final finest adjustment being then secured by an adjusting pin ground into the top, and a gold plating.
Enclosed in polished mahogany, plush-lined lock case.

Duty Free, **$32.50**

16–15 STANDARD NORMAL GRAM, constructed from a single piece of platinum-iridium, trimmed and adjusted with the same nicety as the above.
Enclosed in polished mahogany, plush-lined lock case.

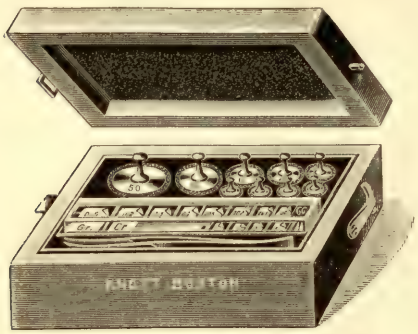
Duty Free, **$16.75**

16–20 STANDARD NORMAL WEIGHTS, each weight constructed from the hardest attainable hard-drawn brass wire turned to shape, trimmed and adjusted with the same painstaking accuracy as the above. Fractional weights are of platinum, adjusted to finest possible accuracy. Set from 1 milligram up to 100 grams, enclosed in polished mahogany, plush-lined case.

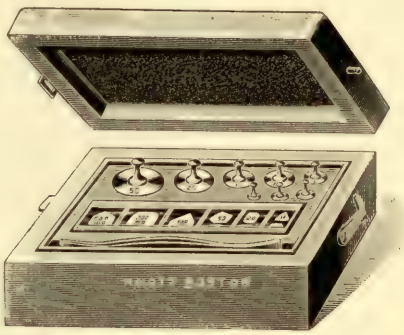
Duty Free, **$38.00**

PRECISION AND ANALYTICAL WEIGHTS

The following weights, Nos. **16–50** to **16–125** are the highest quality precision weights adjusted to highest degree of accuracy. Turned from hard-drawn brass rod, they are more solid, hard and durable than cast weights and much superior from standpoint of permanent accuracy.



Nos. 16–50



Nos. 16–70

16–50 **PRECISION WEIGHTS,** gold-plated. Fractional weights 500 to 10 milligrams are of platinum, the smaller ones of aluminum. One milligram up to 50 grams, with ivory-pointed forceps and camel's-hair brush in velvet-lined, highly polished mahogany case with removable lid. Price from Stock **$12.00**
Duty Free **8.85**

16–52 **PRECISION WEIGHTS,** same as above, but 1 milligram up to 100 grams . . . . . Duty Free **10.00**

16–54 ——, same as above, but 1 milligram up to 200 grams . . . . . Duty Free **13.90**

16–56 ——, same as above, but 1 milligram up to 500 grams . . . . . Duty Free **18.80**

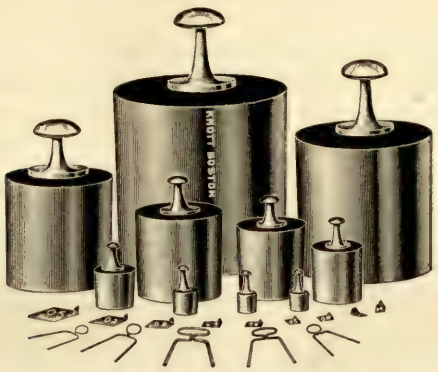
16–58 ——, same as above, but 1 milligram up to 1000 grams . . . . . Duty Free **24.60**

NOTE.—Nos. **16–52** to **16–58** may be obtained platinum-plated if so desired. In view, however, of the market fluctuations in price of platinum, above weights platinum-plated will be quoted on application.

16–70 **ANALYTICAL WEIGHTS,** gold-plated, similar to Nos. **16–50** to **16–58**, but of different though as accurate adjustment, and enclosed in case of cheaper construction. One milligram up to 50 grams
Duty Free **7.75**

16–72 **ANAYLTICAL WEIGHTS**, same as above, but 1 milligram up to 100 grams . . . . . Duty Free **8.90**

16–74 ——, same as above, but 1 milligram up to 1000 grams . . . . . Duty Free **18.75**



Nos. 16–80 to 16–100

16–80 ANALYTICAL WEIGHTS, single weights, gold plated, minutely adjusted, as used in sets Nos. **16–70** to **16–74**.

	a	b	c	d	e	f	g	h	i	j
Size, grams	1	2	5	10	20	50	100	200	500	1000
Each . . .	**$0.60**	**$0.75**	**$0.95**	**$1.35**	**$1.60**	**$1.90**	**$2.40**	**$3.10**	**$4.25**	**$5.85**

16–90 ANALYTICAL FRACTIONAL WEIGHTS, single weights, — 500 to 10-milligram weights of platinum; 5 to 1-milligram weights of aluminum, as used in sets Nos. **16–70** to **16–74**.

	a	b	c	d	e	f	g	h	i
Size, milligrams	1	2	5	10	20	50	100	200	500
Each	**$0.20**	**$0.20**	**$0.20**	**$0.30**	**$0.35**	**$0.45**	**$0.75**	**$1.10**	**$1.95**

16–100 ANALYTICAL RIDER WEIGHTS, single weights of solid gold.

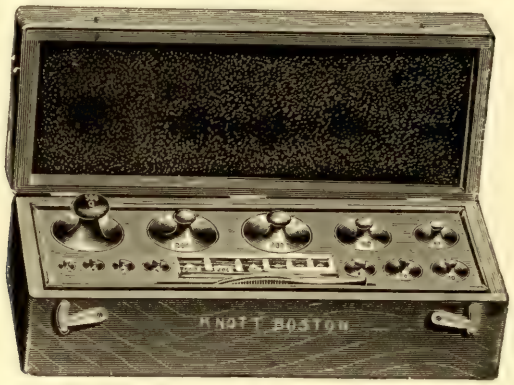
	a	b	c	d	e
Size, milligrams . .	1	2	5	10	12
Each	**$0.40**	**$0.40**	**$0.25**	**$0.25**	**$0.25**

For other **SINGLE WEIGHTS, FRACTIONAL WEIGHTS,** and **RIDERS,** see Nos. **16–350** to **16–370.**

16–125 ANALYTICAL WEIGHTS, platinum, 1 gram down to 1/10 milligram. In highly polished mahogany case . . . . . Duty Free **$8.00**

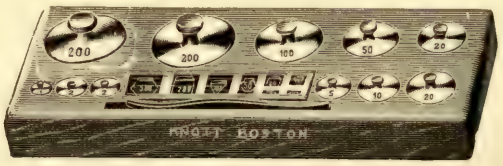
TECHNICAL WEIGHTS

The weights under this heading are intended for technical purposes. They are carefully adjusted but not to the same degree of accuracy as our Precision and Analytical Weights. Single weights are made of hard-drawn brass rods turned to weights, neatly lacquered and then adjusted.



No. 16–154

16–150	**WEIGHTS,** 1 milligram to 20 grams, in highly-polished mahogany case with cover. Fractional weights, 500 to 10 milligrams of German silver; 5 to 1 milligram of aluminum; with forceps, under stout glass plate		**$2.90**
16–151	——, same as above, but 1 milligram to 50 grams		**3.30**
16–152	——, same as above, but 1 milligram to 100 grams		**4.40**
16–153	——, same as above, but 1 milligram to 200 grams	Duty Free	**4.25**
16–154	——, same as above, but 1 milligram to 500 grams	Duty Free	**5.90**
16–155	——, same as above, but 1 milligram to 1000 grams	Duty Free	**11.25**



No. 16–178

16–175	**WEIGHTS,** same quality as above, but in highly polished pear-wood block, fractions under a glass cover. One milligram up to 20 grams; with forceps	**$1.80**
16–176	——, same as above, but 1 milligram up to 50 grams	**2.15**
16–177	——, same as above, but 1 milligram up to 100 grams	**2.50**
16–178	——, same as above, but 1 milligram up to 200 grams	**3.50**
16–179	——, same as above, but 1 milligram up to 500 grams	**5.20**
16–180	——, same as above, but 1 milligram up to 1000 grams	**7.85**

FORCEPS

When transferring weights from box or block to pans, or vice versa, moisture may attach to weights from fingers, thus impairing accuracy of result. It is, therefore, essential for accurate weighing that weights never be transferred by the fingers, but by forceps.

No. 16–227

No. 16–230

16–225 ALL-IVORY FORCEPS, 11 centimeters long, best quality . . . . . Each **$1.40**

16–227 IVORY-POINTED BRASS FORCEPS, 11 centimeters long . . . . . Each **.75**

16–230 LACQUERED BRASS FORCEPS, 10 centimeters long . . . . . Each **.16**

CAMEL'S-HAIR BRUSH

As dirt accumulates on delicate parts of balance, as well as on weights, thus endangering the accuracy, it is always desirable to have a soft brush for dusting these parts. We list below the size which we have found most convenient. Prices of other sizes upon application.

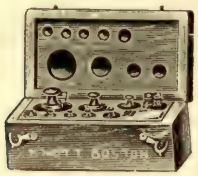
No. 16–250

16–250 FLAT CAMEL'S-HAIR BRUSH, ½ inch wide, best quality **$0.16**

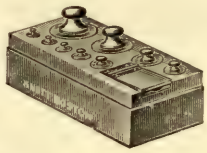
GENERAL LABORATORY WEIGHTS

These weights are intended for ordinary weighing in laboratory, as well as for experiments in "Mechanics," etc., where accuracy of weights need not be greater than percentage accuracy possible with the apparatus used.

For more accurate weights, see preceding pages.



Nos. 16–300 to 16–302



Nos. 16–310 to 16–315

16–300 BRASS WEIGHTS, 1 centigram up to 50 grams, in polished hardwood box with cover **$1.45**

16–302 ——, same as above, 1 centigram up to 100 grams **1.80**

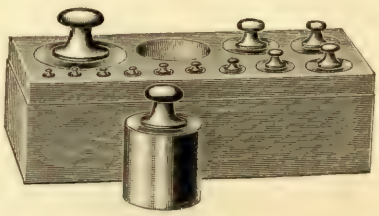
NOTE.—We recommend these weights in covered boxes, because there is less risk of loss and the weights are kept free from dust.

16–310 BRASS WEIGHTS, same quality as above, but in block; 1 centigram up to 20 grams . . . . . **.55**

16–312 ——, same as above, 1 centigram up to 50 grams . . . . . **.85**

16–315 ——, same as above, 1 centigram up to 100 grams **1.30**

No. 16–325

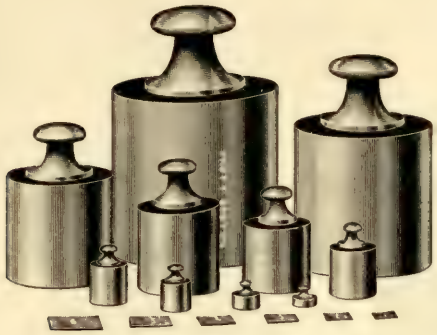


No. 16–327

16–325 BRASS WEIGHTS, same quality as above, but without fractional weights, 1 gram up to 500 grams . **$2.20**

16–327 ——, same as above, 1 gram up to 1000 grams **3.50**

NOTE — The use of **No. 16-325** or **16-327** is recommended with Trip Scale **No. 15-160** or **15-165,** as no smaller weights than 1 gram are needed.



Nos. 16–350 to 16–355

16–350 SEPARATE BRASS WEIGHTS, as used in "General Laboratory Weights."

	a	b	c	d	e	f	g	h	i	j
Size, grams	1	2	5	10	20	50	100	200	500	1000
Each . . .	**$0.07**	**$0.08**	**$0.10**	**$0.12**	**$0.15**	**$0.18**	**$0.27**	**$0.60**	**$0.70**	**$1.25**

16–355 SEPARATE FRACTIONAL WEIGHTS of German silver, as used in "General Laboratory Weights."

	a	b	c	d	e	f	g	h	i
Size, milligrams . . .	1	2	5	10	20	50	100	200	500
Each	**$0.06**	**$0.06**	**$0.06**	**$0.06**	**$0.06**	**$0.06**	**$0.06**	**$0.06**	**$0.06**

16–360 FRACTIONAL WEIGHTS, German silver and aluminum, one each listed under No. **16–355**, with duplicates of the 2, 20 and 200-milligram weights. In cardboard box . . . . . Per Set **$0.50**

No. 16–370

16–370 FRACTIONAL WEIGHTS, German silver, as listed under No. **16–360** but in neat wooden, slide-top box with separate compartment for each size weight **$0.95**

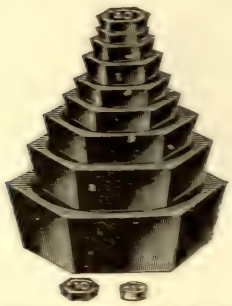
No. 16–380

No. 16–385

16–380 AVOIRDUPOIS BRASS WEIGHTS, ⅛ ounce up to 1 pound. In block **$3.00**

16–385 TROY BRASS WEIGHTS, ½ drachm up to 1 ounce. This set is highly recommended for its pedagogic value in teaching the relation of the Troy system and the other systems of weights . . **1.10**

IRON WEIGHTS



Nos. 16–425 to 16–430

Iron weights have become practically universally used in mechanical powers experiments, with sonometers, etc.

No. 16–440

16–425 OCTAGONAL IRON WEIGHTS, 5 grams up to 1 kilogram . . . . . Per Set **$1.40**

16–430 OCTAGONAL IRON WEIGHTS, 5 grams up to 2 kilograms . . . . . Per Set **2.00**

No. 16–450

16–440 DISC IRON WEIGHTS, 1 ounce up to 16 ounces. Set comprises weights of 1, 2, 4, and 8 ounces with duplicate of the 1 ounce . . . . . **.75**

16–450 INTERHOOKING LABORATORY WEIGHTS for general utility in the Physical Laboratory in the study of mechanical advantages of simple machines.

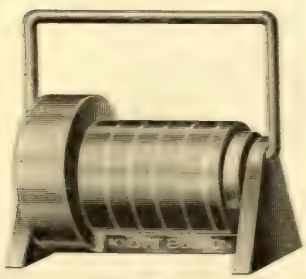
These weights are accurately adjusted from cast hexagonal blocks of iron, of a design permitting the attaching of one weight to the other by a hook, the top of one to the bottom of the other, the hooking attachment in the bottoms, however, not hindering standing each weight upright. The set consists of a 10, 20, 50, 100, 200, 500, and 1000 gram weight, with duplicates of the 20 and the 200-gram pieces. Each weight fits readily into an apartment in a neatly japanned cast-metal holder.

Set complete with holder **2.50**

16–452 INTERHOOKING LABORATORY WEIGHTS. Set complete as above but without holder . . . **2.00**

16–453 CAST METAL HOLDER with separate compartment for each weight listed above **$0.65**

16–460 SLOTTED METRIC WEIGHTS, accurately adjusted. Set of 1–500, 5–100 1–50, 2–20, and 1–10 gram weights mounted on japanned holder . . . **1.70**



No. 16–460

16–477 SLOTTED METRIC WEIGHTS and WEIGHT HANGER for use in mechanical powers experiments where large capacity weights are not needed. Consists of a nickel-plated brass hanger accurately adjusted to 50 grams weight, and a set of weights same quality and as listed in No. **16–460**—1–500, 5–100, 1–50, 2–20, and 1–10 gram weights.

Set complete with hanger **2.20**

16–478 SLOTTED METRIC WEIGHTS, separate weights same quality as listed above.

	a	b	c	d	e
Size, grams	10	20	50	100	500
Each	**$0.18**	**.22**	**.28**	**.44**	**.58**

No. 16–477

16–479 WEIGHT HANGER, accurately adjusted to weigh 50 grams. Nickel plated. Same as used in No. **16–477** **$0.50**

Nos. 16–485 to 16–500

ADJUSTED METRIC CAST-IRON WEIGHTS with Pratt Institute safety slot, for use in Mechanical Powers experiments where weights of large capacity are needed.

These weights are made from carefully-designed patterns, provided with groove and raised ring which enables them to be readily piled on top of one another without danger of slipping and producing confusion in the lecture room or laboratory.

The slot in each is made slightly narrower than the diameter of the hole in the center, enabling the weight to be easily put on and taken off from the Pratt Institute Weight Hanger listed below, and at the same time, preventing the weights from accidentally falling from the hanger. See above cut.

These weights, being made of the finest quality of castings, carefully adjusted, may be depended upon for careful work.

16–485	**a**	**b**	**c**	**d**
Size, kilos	½	1	2	5
Each	**$0.48**	**.57**	**.75**	**1.50**

16–487 WEIGHT HANGER, Pratt Institute design.

All of our hangers in this group are made with the upper portion of the rod cut away to fit the slot in the weight, while the main part of the rod is the same size as the hole in the center of the weight. This insures the weights being held securely in position, making it impossible for them to accidentally fall off, and at the same time rendering it easy to put them on and take them from the hanger without removing the hook from its support. This feature adds materially to the ease of their use in the laboratory and is indispensible where large laboratory divisions are a necessity.

Hanger accurately adjusted to weigh 500 grams **$0.90**

16–489 SLOTTED METRIC WEIGHTS WITH WEIGHT HANGER. Set consists of one each weights listed under No. **16–485** and No. **16–487** Weight Hanger **4.15**

UNADJUSTED IRON WEIGHTS for Applied Physics, after designs as used in the Pratt Institute, and first made for the Wentworth Institute in Boston.

These weights are designed for Mechanical Powers experiments in Applied Physics. While not adjusted to exact weights, being cast uniformly from carefully adjusted patterns, they are sufficiently accurate for all the uses for which they are designed.

As may be noted from the illustration, there are three series. The slots in all the weights are of uniform size. The rods on all the hangers are of the same size, the only difference being in the size of the supporting disc and in the length of the supporting rod.

We recommend Hanger d for Weights **a**, **b** and **c**; Hanger g for Weights **e** and **f**, and Hanger j for Weights **h** and **i**. (See tabulation below.)

16–500	SERIES 1				SERIES 2			SERIES 3		
	Weights			Hanger	Weights		Hanger	Weights		Hanger
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**
Size, pounds	¼	½	1		2	5		10	20	
Each	**$0.11**	**.14**	**.18**	**.45**	**$0.27**	**.68**	**.52**	**$1.07**	**1.74**	**.90**

16–520 SAFETY VALVE WEIGHT. Cast iron weight with slot in handle.

	a	**b**
Size, pounds	4	7
Each	**$0.45**	**$0.80**

TIME—INDICATORS—SPEED

CLOCKS, PENDULUMS, METRONOMES, ETC.; SPEEDOMETERS

No. 17–10

17–10 LABORATORY CLOCK for general use as an accurate time-keeper and especially adapted for beating seconds.

This clock has an eight-day, standard movement, weight driven, and we guarantee its reliability as an accurate time-keeper. The lens-shaped bob is of polished brass and the pendulum is full seconds length, the center of oscillation being readily adjusted by means of a thumb-screw. The dial, designed especially for laboratory usage, is not confused by the usual large hour numerals, for, since in laboratory practice seconds beats are essential, the seconds divisions are the most prominent. Thus in our dial, the hour and minute divisions with their hands are small, while the seconds divisions are large and the seconds hand is long. All three, however, are sufficient in size to be readily seen from any part of the laboratory.

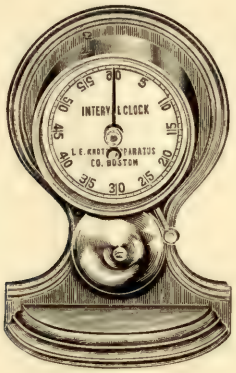
The mercury well is our improved design, exposing a thin strip of mercury which is readily adjusted by means of an easily accessible knurled thumb-screw. This well is mounted in a metal frame in which it has a further adjustment. A graduated arc attached to this frame has been found an excellent simple device for leveling, when setting up the clock in the laboratory.

The case of our clock is made of polished mahogany, designed practically dust-proof. It is, in appearance, equal to the excellent quality of the movement which it contains. It is provided with binding posts for electrical connections for attaching battery and sounder **$55.00**

17–15 MAGNETIC CLOCK CONTACT for attachment to any laboratory clock, making an adjustable positive contact that cannot get out of order.

The design of a magnetic clock contact was first suggested to avoid the disagreeable features accompanying a mercury contact. In our design we have incorporated an ingenious device of our own which is designed to obviate a great part of the work required on the part of the pendulum. The contact is positive and the make-and-break instantaneous. It is readily attached to any seconds pendulum or any make laboratory clock with swinging pendulum.

Complete, ready for attachment **12.00**



No. 17–25

17–25 INTERVAL TIMER for accurately indicating any interval of time from 1 minute up to 4 hours. This timer is not a clock in that it does not indicate time of day, but it does accurately time any desired interval up to 4 hours announcing the end of the period by the ringing of the bell. It is wound like a clock and looks like a clock. It will run about 35 hours with one winding and with ordinary care will not get out of order.

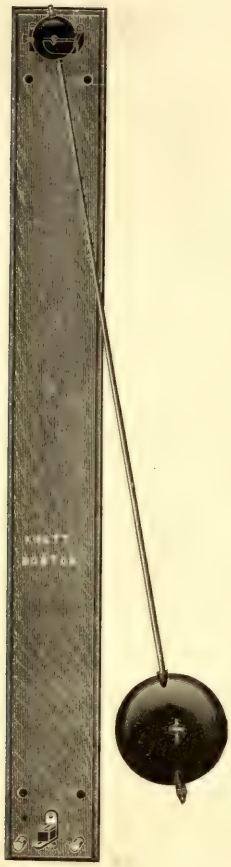
Complete with simple directions for care and use **$4.95**

No. 17–40

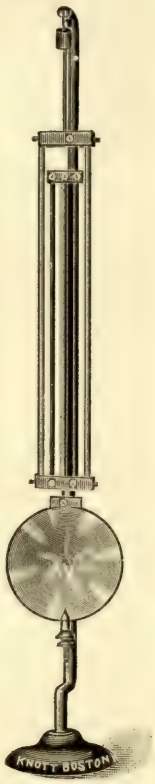
17–40 DISSECTED CLOCK, for student's use in the study of the mechanical principles involved in construction of weight-driven clocks. All parts are mounted on card neatly numbered or lettered for easy reference. All parts being substantially built and accurately fitted, no tools are necessary in assembling. Being of simple construction, no mechanical skill is needed to assemble, — directions furnished with each clock being full and simple. Assembled, the clock will keep good time.

This clock is highly recommended for its educational value in making clear the complexity of parts of an expensive time-keeper. It has the further value of increasing the interest of the student.

Complete, with full directions, in a neat box **$1.65**



No. 17–50



No. 17–60

No. 17–75

17–50 FULL-SWEEP SECONDS PENDULUM for beating seconds in experimental determinations in laboratories where the more expensive laboratory clock is not available.

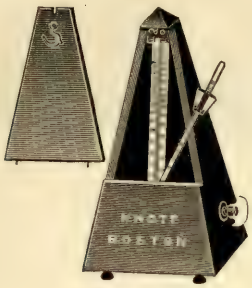
This pendulum consists of a full-sweep seconds pendulum with metal bob, cast lens-shape to overcome air resistance, and suspended on ground and polished steel edges in a special stirrup. It is mounted on polished hardwood board with an adjustable mercury well designed to expose a thin strip of mercury sufficient to cause a positive sure contact. This mercury is adjusted by means of a screw, and the well may be adjusted back out of the way at will. Further adjustment is possible by the adjustable contact tip. Binding posts are conveniently placed for connection of battery and sounder **$6.90**

17–60 COMPENSATING PENDULUM, illustrating employment of metals having different coefficients of expansion in keeping the distance between the center of suspension and the center of oscillation constant. Consists of alternate rods of zinc and iron, so attached that the expansion of one is compensated by the expansion of the other. Mounted on neatly finished adjustable tripod stand . . **12.35**

17–75 COMPENSATING MERCURY PENDULUM, an accurately constructed, handsomely finished full-length seconds pendulum, compensated by the expansion of mercury.

This design, a modification of the Graham's mercury pendulum, is one of our own. It consists of a steel rod as in a simple seconds pendulum, but in place of the disc bob are suspended two glass mercury wells in suitable holders. All adjustments are provided. Simply operated and effectively working. The apparatus is handsomely finished throughout and the quality of workmanship is of the finest.

Complete as illustrated with stirrup, but without mercury **9.90**



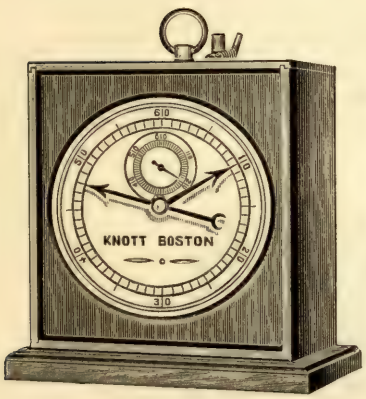
No. 17–120

No. 17–150

17–120 METRONOME, for time-marking in laboratory experiments in the study of Falling Body, Pendulum experiments, etc. This instrument has a graduated scale and a marker operated by spring-driven clockwork enclosed in polished mahogany case **$3.50**

17–125 METRONOME WITH BELL. This is the same quality Metronome as above, but has the additional feature of a bell attachment which can be regulated to sound every beat, every second, third or fourth beat as desired **5.35**

17–150 STOP WATCH, an indispensable accessory to the equipment of any well-equipped laboratory. This watch is of excellent quality, stem wound, lever movement, beating one-fifth seconds, neatly polished nickel case with stop **7.10**



No. 17–165

No. 17–200

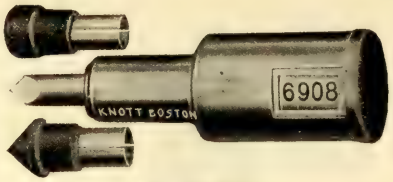
17–165 STOP CLOCK, with 5-inch dial and with seconds hand. In highly-polished mahogany case. Designed to be hung on the wall or placed on a table. This clock is an accurate time keeper, having the distinctive feature of being an inexpensive stop clock with qualities that would warrant its adoption in class-room demonstrations . . . . . Duty Free **$9.80**

17–200 UNIVERSAL SUN DIAL. In our Sun Dial, which may be adapted to any Latitude, we offer an instrument scientific in design and capable of accurate work. It is 12 inches square, substantially constructed of metal and can be continuously exposed without injury in any climate. By an ingenious arrangement, not illustrated, a correct setting for any latitude can easily be obtained. We supply with each instrument a printed form on which a correction curve for any locality can readily be plotted from full and explicit directions furnished with each instrument.

Each instrument is durably finished with a protective coating, the figures and lines showing in colors against the black finish on the casting.

Universal Sun Dial, complete with directions for correct setting for any Latitude, directions for plotting correction curve, and printed form for same **7.50**

No. 17–300



No. 17–305

17–300 IMPROVED SPEED INDICATOR, for measuring speed of rotation of shafts in efficiency experiments, etc. As there is a patented frictionless bearing against which the inner end of the spindle bearing the indicator revolves, this indicator may be run as well on high as low speed without overheating. As all working parts are entirely enclosed, dirt cannot accumulate to clog free movement of dial.

The graduations show every revolution and with two rows of figures which read both right and left. The two raised knobs which may be noted in the illustration are an added improvement to this indicator. As the inner disc is carried by friction it may be moved to the starting point where the raised knobs coincide, then pressed to prevent rotation while hands of the watch get into the right position for the time. When released, this inner disc will be carried around by friction and if the thumb is held tightly on the surface of the dial the eyes need not leave the watch face, as each 100 revolutions may be noted as the knob passes under the thumb.

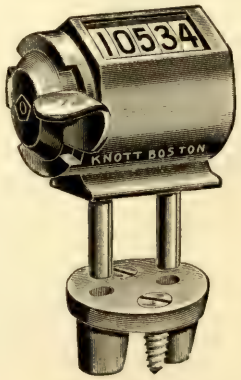
This instrument is nickel plated. Enclosed in neat box **$1.00**

17–305 SELF-REGISTERING SPEED INDICATOR. This compact instrument registers directly by index wheel the actual number of revolutions. In operating, press the point lightly against the end of the shaft; then, when the seconds hand of the watch has come to zero, press on the end of the counter, and it will instantly begin to count. At the end of the minute release the pressure and the counter stops instantly. By taking the reading of the register before and after, the number of revolutions per minute can readily be determined. When the shaft turns one way the counter adds; when it turns the other way, it subtracts. It works equally well in either direction.

This counter will register up to 9,999 revolutions and can be used equally well on high or low speed machinery, and speeds as high as 5,000 R. P. M. can safely be determined.

Each counter is supplied with two rubber tips, one pointed, the other flat. They serve as insulators when taking the speed of electrical machinery, and the flat tip is to be used on shafts with flat ends **3.40**

No. 17–310



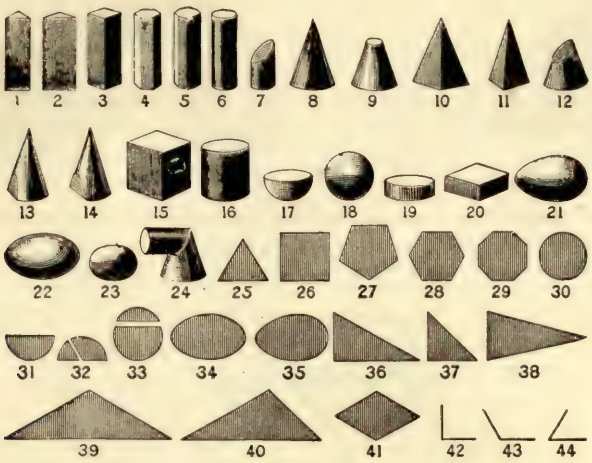
No. 17–325

17–310 SELF-REGISTERING SPEED COUNTER, registering directly the number of revolutions, either backward or forward. If run backward, will count backward. Illustration shows instrument attached to flange base which is the most popular method of mounting. Will register up to 99,999 revolutions **$1.50**

17–325 SELF-REGISTERING HAND COUNTER, for attaching to table or wooden support, and to be operated by slight hand pressure upon the small lever shown in the illustration.

Complete with nickel-plated socket plate **2.00**

MATHEMATICAL MODELS



No. 18–10

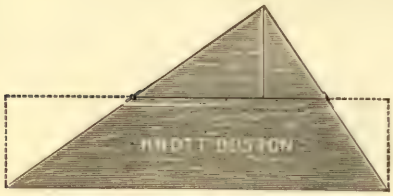
18–10 **GEOMETRICAL WOODEN FORMS,** consisting of twenty four solids, seventeen surfaces, and three angles, the latter being represented by bent wires. Solids are accurately turned from well-seasoned hard wood, surfaces cut with accurate steel dies from stiff, hard, light-colored board. Complete in strong wooden box, with table of contents pasted on the under side of the cover . . . **$2.95**

No. 18–20

18–20 **CONE, SPHERE, and CYLINDER,** for ocular demonstration of the relation between the contents of cone, sphere, and cylinder. The cone and cylinder are 3 inches deep by 3 inches in diameter. Actual demonstration shows that the cone, three times filled with water, fills the cylinder, and that the cylinder filled with water and sphere submerged, enough water will remain in the cylinder to fill the cone, thus showing that their contents are as the ratio **1**: **2**: **3** . . . . . Per Set **$1.25**

No. 18–30

18–30 **DISSECTIBLE CONE,** for illustrating conic sections: circle, ellipse, parabola, and hyperbola. This cone is made of different kinds of hard wood, highly polished on the surface, each section held by large pins. Being of ample proportions, sections are of convenient demonstrating sizes **$3.15**

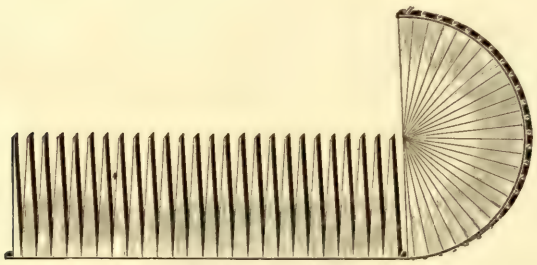


No. 18–40 (Fig. 1)

No. 18–40 (Fig. 2)

18–40 TRIANGLE DEMONSTRATION APPARATUS, for demonstrating mechanically that the area of a triangle is equal to its base multiplied by one-half its altitude.

The apparatus consists of two triangles so hinged that by simply swinging certain parts on their hinges, the triangles resolve themselves into two rectangles 12 inches long by 3 inches high. **Fig. 1** illustrates the problem when a perpendicular from the apex drops within the base, and **Fig. 2**, when the perpendicular falls outside the base . . . . . Per Set of Two **$1.90**



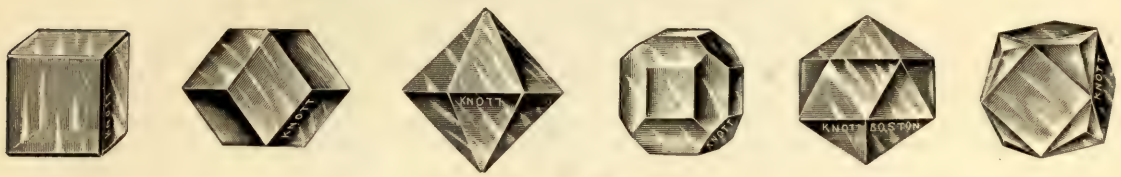
No. 18–50

18–50 CIRCLE AREA DEMONSTRATION APPARATUS, for demonstrating mechanically that the area of a circle is equal to the radius multiplied by one-half the circumference. The apparatus consists of a large number of sectors attached at their bases by a pliable band connecting them by hinges. This band is in two parts, so that the circle made of sectors may be separated into two semi-circles. When these two semi-circles are straightened out, two toothed forms result. By inserting the teeth of one form between the teeth of the other a rectangle is formed. The base of this rectangle, then, is a semi-circumference and its height the radius of the circle. The diameter of disc is 8 inches . . . **$2.10**

No. 18–60

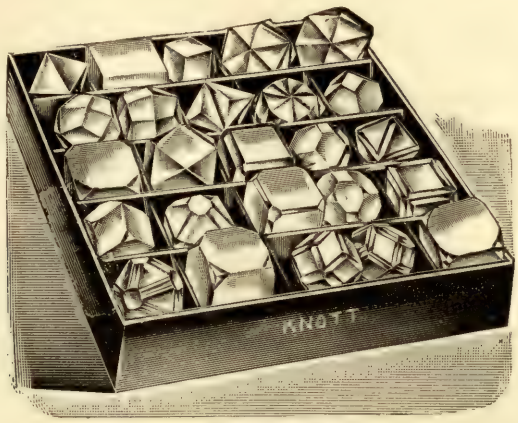
18–60 CUBE ROOT BLOCKS, for illustrating in a simple manner the underlying principles of cube root extraction. The apparatus consists of an accurately dissectible wooden cube, the size of the inner cube being 3 inches on an edge and the assembled cube being 4 inches **$2.00**

MODELS OF CRYSTALS



No. 18–125

18–125 **CRYSTAL MODELS OF SOLID GLASS,** a set consisting of six models, representing the six basic geometrical forms. In neat cardboard case **$4.75**



No. 18–135

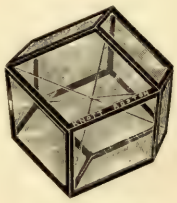
18–130 **CRYSTAL MODELS OF SOLID GLASS,** a set of twenty different forms, surfaces ground and polished, axis 3 to 6 centimeters in length. Enclosed in case . . . . . Duty Free **$8.00**

18–135 **CRYSTAL MODELS OF SOLID GLASS,** a set of twenty-five different forms, surfaces ground and polished, axis 3 to 6 centimeters. Enclosed in fine lined case . . . . . Duty Free **16.50**

18–140 **CRYSTAL MODELS OF SOLID GLASS,** a set of thirty different forms, surfaces ground and polished, axis 3 to 6 centimeters. Enclosed in fine lined case . . . . . Duty Free **18.00**

18–145 **CRYSTAL MODELS OF SOLID GLASS,** a set of sixty different forms, surfaces ground and polished, axis 3 to 6 centimeters. Enclosed in fine lined case . . . . . Duty Free **32.00**

18–150 **CRYSTAL MODELS OF SOLID GLASS,** a set of ninety different forms, surfaces ground and polished, axis 3 to 6 centimeters. Enclosed in fine lined case. . . . . Duty Free **40.00**



No. 18–175

18–175 **CRYSTAL MODELS,** a set constructed of glass plates, axes indicated by colored silk strings. Length of axis, 15 to 25 centimeters. This collection illustrates the simplest basic formations. Set of fifteen models . . . . . Duty Free **$24.25**

18–177 **CRYSTAL MODELS,** a set constructed as above, but including thirty different models . Duty Free **48.50**

18–200 **CRYSTAL MODELS OF WOOD,** consisting of thirteen different forms, representing the most common crystal formations. In cardboard box **2.60**

18–205 **CRYSTAL MODELS OF WOOD,** consisting of twenty different forms, constructed from finest grain hardwood, axis length 5 centimeters . . . . . Duty Free **8.25**

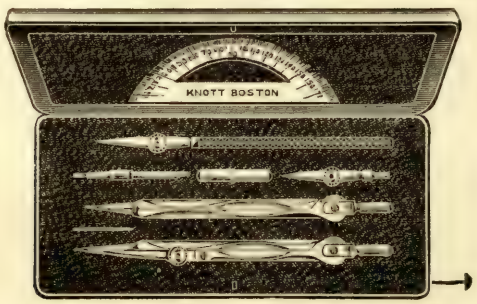
18–210 **CRYSTAL MODELS OF WOOD,** consisting of forty different forms, constructed from finest grain hardwood, axis length 5 centimeters . . . . . Duty Free **13.50**

18–215 **CRYSTAL MODELS OF WOOD,** consisting of sixty different forms, constructed from finest grain hardwood, axis length 5 centimeters . . . . . Duty Free **21.00**

DRAWING INSTRUMENTS

In listing our line of drawing instruments, we have in mind the elementary requirements for such a class of goods, yet we believe that fewer instruments, rather than cheaper grade, are advisable if the school's appropriations will not warrant the expenditure for such instruments.

The line of instruments which we list are made of hard-pressed German Silver, and finished steel. They have received all the improvements of fine tools and will be found capable of very exact work.

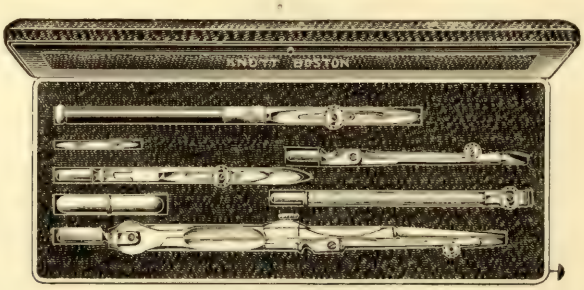


No. 19–10

19–10 DRAWING INSTRUMENTS, good quality hard-pressed German silver and polished steel, containing the following instruments, in a neat leather case, lined with velvet:

Ruling Pen, 5 inches, with patented spring back lever.
Compass, 5½ inches, with fixed needle point, pen, and pencil point.
Plain dividers, 5½ inches.
Metal protractor, 3½ inches.
Box of leads.

Complete set, **$1.50**

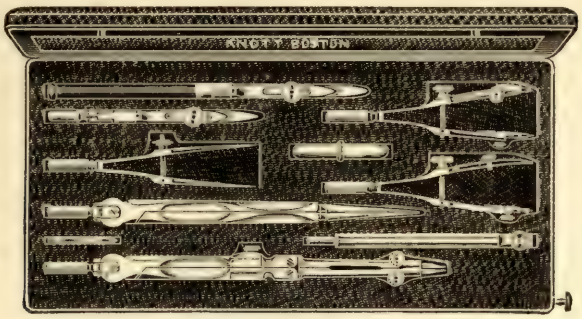


No. 19–12

19–12 DRAWING INSTRUMENTS, extra quality hard-pressed German silver and polished steel. Set containing the following instruments in a neat Morocco pocket case lined with velvet:

Ruling pen, 5½ inches, with patented spring back lever.
Compass, 6 inches, with fixed needle point, pen, pencil point, and lengthening bar.
Steel divider point.
Box with leads.

Complete set, **$2.65**

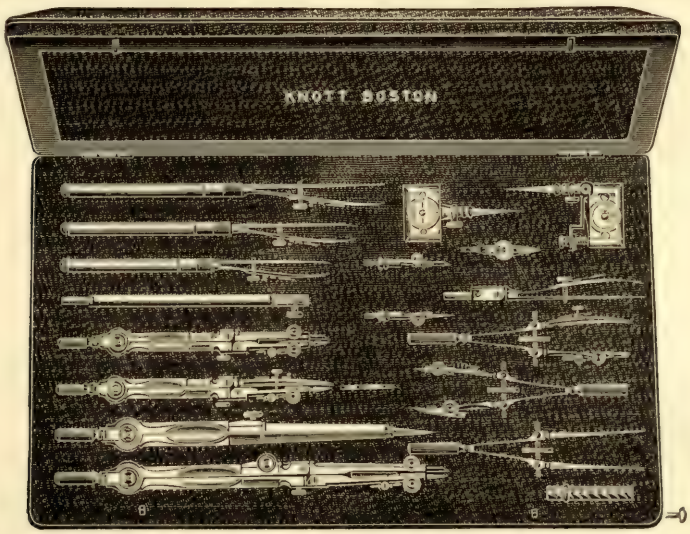


No. 19–14

19–14 DRAWING INSTRUMENTS, extra quality hard-pressed German silver and polished steel. Set containing the following instruments, in Morocco pocket case lined with silk velvet:

Ruling pen, 5 inches, with patented spring steel back.
Plain Divider, 6 inches.
Compass, 6 inches, with fixed needle point, pen, pencil point, and lengthening bar.
Steel spring bow pencil, 3½ inches.
Steel spring bow pen, 3½ inches.
Steel spring bow divider, 3½ inches.
Box of leads.

Price, complete **$4.80**



No. 19–16

19–16 DRAWING INSTRUMENTS, superior quality, draughtsman's tools, constructed of hard-pressed German silver and polished steel, with patented improved devices greatly increasing the utility. Set containing the following instruments in morocco pocket case, lined with chamois:

Three ruling pens, 5½, 5, and 4½ inches long, each with patented release lever, ebony handle.
Compass, 6 inches long, improved pivot joint, patented straightening device, fixed needle-point with patented needle regulator, pen point with patented release lever, pencil point and lengthening bar and lead box.
Hairspring divider, 5½ inches long, improved pivot joint, patented straightening device, with long steel points.
Compass, 4 inches long, improved pivot joint, patented straightening device, fixed needle point with patented needle regulator, pen point with patented release lever, and pencil point.
Compass, 4 inches long, improved pivot joint, patented straightening device, fixed needle point with patented needle regulator, fixed pen point with patented release lever.
Steel spring bow divider, 3½ inches long, German silver handle.
Steel spring bow pen, 3½ inches long, German silver handle.
Steel spring bow pencil, 3½ inches long, German silver handle.
Beam compass, three parts: needle point, pen point, pencil point.

Duty Free **$14.50**

No. 19–23

19–20 **SCHOOL COMPASS,** as illustrated in set No. **19–10,** with fixed needle point and pencil point . . . **$1.15**

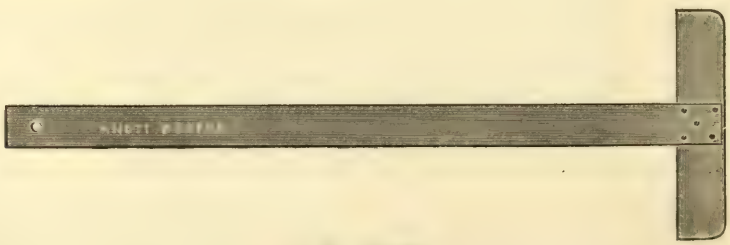
19–23 **UNIVERSAL PENCIL COMPASS** for student's use in diagram work in laboratory. These pencil compasses are inexpensive, yet strong and serviceable. Capable of drawing circles up to 12 inches in diameter.

Complete as illustrated, with pencil . . . . . Per Dozen **1.50**

19–25 **STEEL SPRING BOW DIVIDER,** 3½ inches, as included in sets Nos. **19–10** to **19–14** . . . . . **.72**

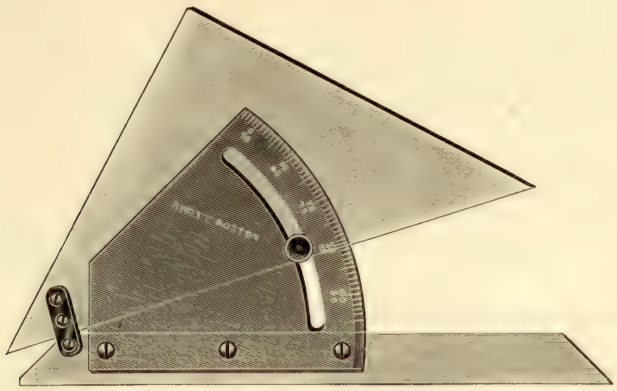
No. 19–30

19–30 **PARALLEL RULE,** best quality, made of clear ebony with brass mountings. Length 12 inches . . . **$1.00**



No. 19–32

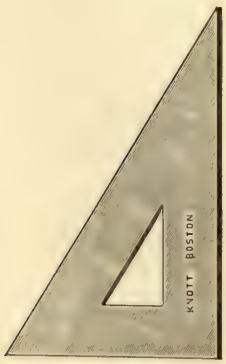
19–32 **T-SQUARE,** cherry wood, 24 inches long, with fixed cross head **$0.35**



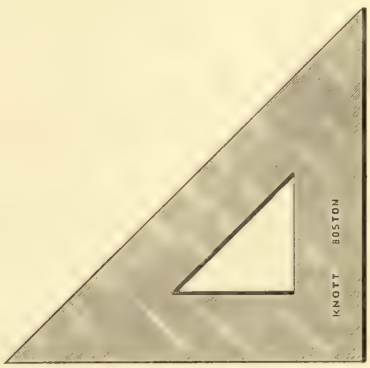
No. 19–34

19–34 AMBRO UNIVERSAL SET SQUARE. This square, imported by us, has many features which can only be realized by use. Designed to secure the same utility as a number of instruments, it has advantages over each, in that it can be instantly adjusted to perform their various duties. It is an accurate protractor, graduated to read from 0 to 90 degrees in two directions; it is an accurate try square; it is a right angle triangle; it is a straight edge, etc., etc.

It is substantially constructed and its accuracy is unexcelled. Its universal adaptation to uses of many instruments at a cost far below that of these instruments is a feature to which we desire to call particular attention **$2.35**



No. 19–42



No. 19–43

19–40 PEARWOOD TRIANGLE, framed, extra quality, 30 degrees. Size 10 inches **$0.26**

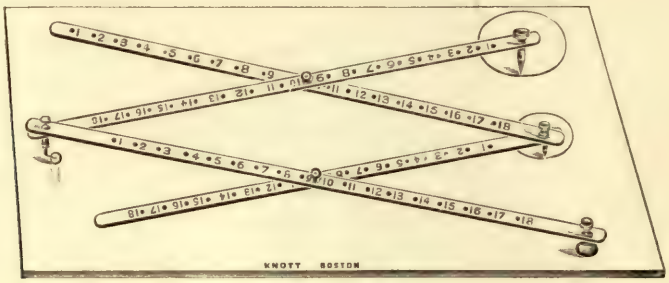
19–41 ——, same as above, but 45 degrees. Size 8 inches . . . . . **.28**

19–42 TRANSPARENT AMBRO TRIANGLE, 30 and 60 degrees. Size 10 inches . . . . . **.77**

19–43 ——, same as above, but 45 degrees. Size 8 inches . . . . . **.77**

19–50 DRAWING BOARDS of clear grained pine wood, having two drawing surfaces, with side ledges.

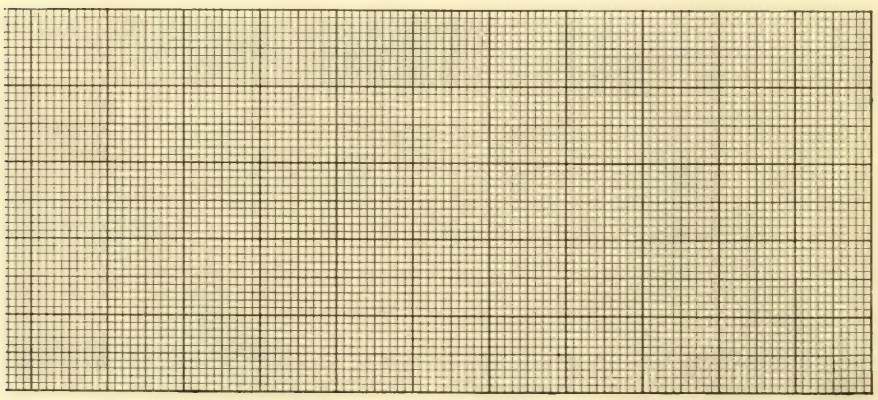
	a	b	c
Size	16 × 22	20 × 24½	23 × 31 inches.
Each	**$1.05**	**1.60**	**2.15**



No. 19–60

19–60 PANTOGRAPH for enlarging or reducing drawings. This instrument is of the highest quality, constructed of polished boxwood with nickel plated mountings. It is supplied with a brass elbow joint, pencil holder, and movable point.
Figures show black on polished wooden surface. Arms 21 inches long.
Complete in box **$2.70**

19–61 PANTOGRAPH, simplest form, similar in design to No. **19–60.** This instrument is brass mounted, with clear black figures on highly polished hardwood. It is provided with movable point . . . . **.90**

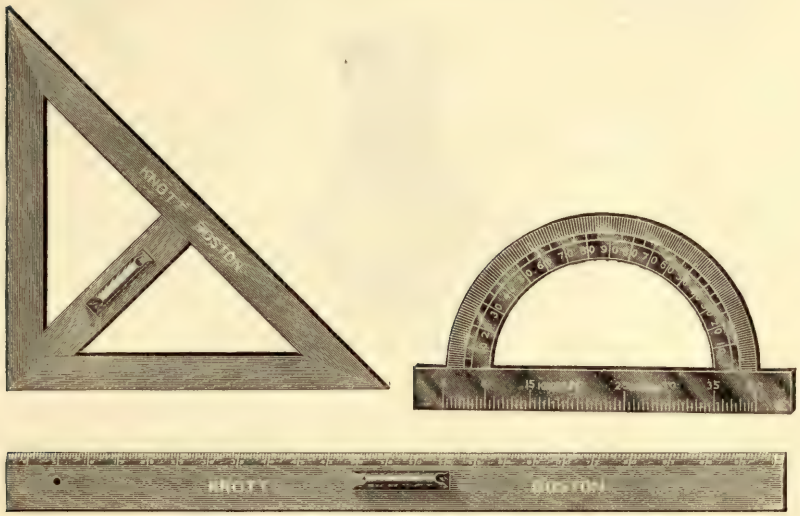


Nos. 19–67 to 19–68

19–65 CROSS–SECTION PAPER. 1/10 inch divisions, printed on heavy bond paper 17 × 22 inches.
Per Sheet **$0.18**

19–67 CROSS–SECTION PAPER. One millimeter division with heavy centimeter rulings 15 × 20 centimeters, on heavy bond paper 8½ × 10½ inches. This is our National Physics Note Book Cross Section Sheet with holes punched for use in our Binders . . . . . Per 100 Sheets **.50**

19–68 CROSS–SECTION PAPER, same ruling as No. **19–67**, but printed on drawing paper 22 × 27 centimeters . . . . . Per 100 Sheets **1.50**



No. 19–75

19–70 BLACK BOARD DIVIDER AND COMPASS. Superior quality, substantially constructed and handsomely finished.

Length 16 inches **$0.60**

19–75 BLACK BOARD DRAWING INSTRUMENTS. Essential where accurately constructed diagrams are required of either teacher or pupil.

These instruments, imported by us, must not be confused with the ordinary quality on the market. The set offered under this number is accurately and substantially constructed, each being provided with conveniently situated handle. The ruler and triangle are of beechwood, the protractor of oak, polished and oil finish. The ruler is a full meter, graduated the full length into clear, distinct, black filled divisions. The triangle, 50 centimeters long, has angles of 45 and 90 degrees. The protractor, 40 centimeters in diameter, has two scales, the linear and angular, the latter reading in two directions, divisions and figures filled black . . . . . Set of Three **4.35**

MECHANICS

PROPERTIES OF MATTER

No. 20–10

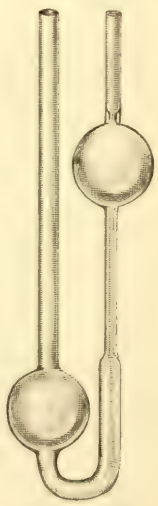
20–10 POROSITY DEMONSTRATION APPARATUS for illustrating the porosity of wood. Apparatus consists of an oak wood funnel, a conveniently sized bell glass and glass dish as illustrated.
In use, the apparatus is placed grouped as illustrated on the plate of an air pump. Mercury is placed in the wood funnel. After a few strokes of the lever, the mercury will begin to run through the pores of the wood into the glass. Complete as illustrated **$1.70**

20–11 WOOD FUNNEL, as used in above . . . . . **.85**

20–12 BELL GLASS, as used in above . . . . . **.85**

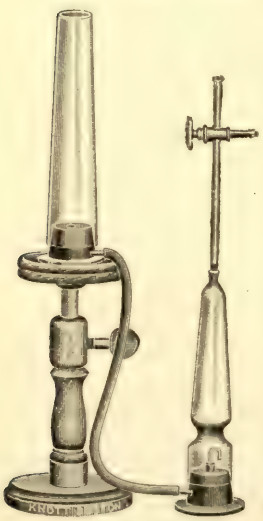
20–13 GLASS DISH, as used in above **$0.10**

20–20 VISCOSITY APPARATUS, for determining the viscosity coefficient of a liquid. Apparatus consists of a capillary tube with bulb so that the time of outflow is at least 100 seconds. The liquid flows under its own pressure to the capillary. An accurately known quantity is introduced into the wider tube and then sucked up the other tube until the liquid has risen above the bulb. The time occupied by the liquid flowing from this height to below the bulb is noted and coefficient determined **1.60**



No. 20–20

20–25 JENKIN'S SPECIFIC GRAVITY OF GAS APPARATUS as used by the Massachusetts gas commission for determining the specific gravity of a gas by the effusion method.



No. 20–25

The apparatus consists of two glass vessels both of which are mounted on a water-tight block, one vessel plain, the other provided with a stop-cock tube fitted with air-tight connection to lower part. A stand is provided for supporting either vessel above the other.

The principle at the basis of this method consists in the time comparison of displacement of equal quantities of a gas and of air. In use, the vessel with stop-cock tube is filled with gas by first displacing air contents by raising plain vessel filled with water until water height reaches mark. If time consumed by water in reaching this mark is noted, we have one factor in our formula. If the outlet of the stop-cock is connected by tube to the gas supply, and the plain vessel is displaced by the vessel with stop-cock tube, this gas will be drawn in to fill the vessel having the stop-cock. If this gas is now forced out as the air was forced out and time noted, we have the other factor of our formula and

Specific Gravity of Gas will equal . . . . $\frac{\text{Time for Gas Displacement}}{\text{Time for Air Displacement}}$

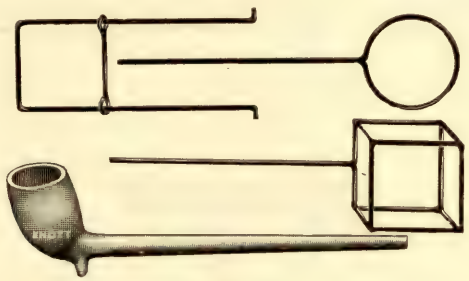
Apparatus complete as illustrated **$7.50**

No. 20–90

No. 20–95

20–90 **LEAD COHESION DISCS,** for illustrating molecular cohesion between metals. Apparatus consists of two hemispheres of lead with faces carefully ground smooth.
When the two surfaces are pressed tightly together, the cohesion between the lead molecules offers a resistance to separation **$0.40**

20–95 **GLASS COHESION DISCS,** for illustrating molecular cohesion between two glass plates. Apparatus consists of two all-glass hemispheres with carefully ground faces.
When the two faces are pressed tightly together, the cohesion between the glass molecules offers a resistance to separation . . . . . **.65**



No. 20–100

20–100 **FILM DEMONSTRATION APPARATUS** for illustrating characteristics of films demonstrating Surface Tension and Cohesion.
The apparatus consists of three wire frames of different forms with pipe for blowing spherical films. Striking results are possible from proper use of these frames. Tendency of all films to attain a circular form is quite noticeable . . . . . Per Set as Illustrated **$0.90**

No. 20–110

No. 20–115

No. 20–117

20–110 **PRINCE RUPERT DROPS,** for illustrating the stress existing between the inside and outside of a glass when it is allowed to cool suddenly. These drops consist of drops of glass which have their surfaces cooled suddenly so that they become rigid, before the inner surface has had time to cool. There is considerable stress, therefore, between the outside and the inside, but, the stress being distributed over the surface, a state of equilibrium exists which is only disturbed when a small portion is broken, when the drop will explode into very small pieces. In use, therefore, the drop should be covered with a piece of paper so that when the small tail is broken off no one will be exposed to the flying fragments . . . . . Per Dozen **$0.25**

20–115 **BOLOGNA PHIALS.** These phials are made in a similar manner to the Prince Rupert Drops and illustrate the stress existing by allowing small pieces of flint to move about inside the flask, thus causing small scratches which results in the bottom flying to pieces. This is a spectacular experiment, as only a very slight scratch will cause the bottom to fly out . . . . . Per Ten **1.50**

20–117 **ADHESION DISC,** for illustrating adhesion between glass and a liquid. Apparatus consists of a circular glass plate, 3 inches in diameter, having at its center a polished wood cone at the apex of which is fastened a fine thread for attachment to a balance arm when experimenting . . Each **.50**

No. 20–125

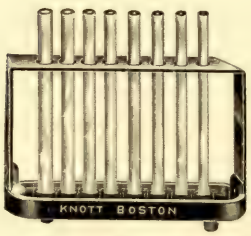
20–125 **GLASS PLATES FOR ILLUSTRATING CAPILLARITY.** Consists of 2 plates of glass, which may be placed in a shallow dish of water at any desired angle, when a curve will result somewhat as illustrated . . . . . Per Pair **$0.25**

20–126 **GLASS PLATE SEPARATOR,** for holding 2 glass plates, as No. **20–125,** at any desired angle in a dish of water. Consists of a small wedge with detents for holding to tops of the plates . . . . . **.50**

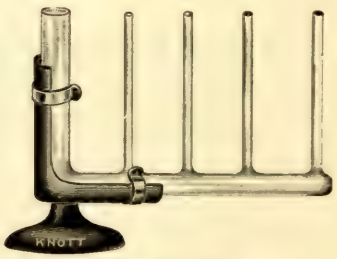
No. 20–130

No. 20–155

Nos. 20–134 and 20–135



No. 20–140



No. 20–150

20–130 **TAPERING CAPILLARY TUBES,** for demonstrating capillarity in tubes. Consists of a tapering glass tube 4 inches long.
This is a very excellent, inexpensive piece of apparatus for demonstrating capillarity in tubes of different diameters **$0.35**

20–132 **CAPILLARY TUBES,** set of 4 tubes of different internal diameters, 4 inches in length . . . Per Set **.33**

20–134 **CAPILLARY TUBES ON SUPPORT,** consisting of a set of four tubes of different diameters, mounted on support, for placing over top of a small jar . . . . . **.44**

20–135 **SMALL JAR,** for use with No. **20–134** Capillary Tubes . . . . . **.10**

20–137 **CAPILLARY TUBES,** set of eight tubes of different internal diameters for illustrating capillarity Per Set **.68**

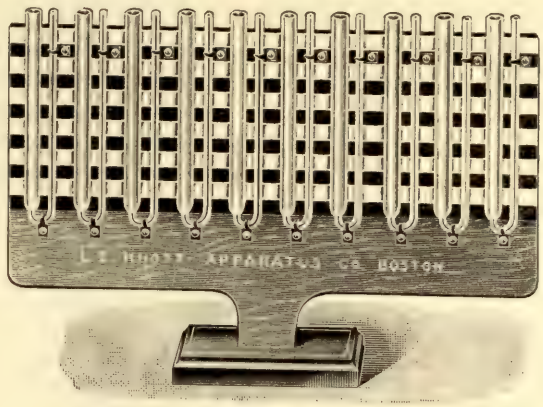
20–140 **CAPILLARY TUBES AND STAND,** consisting of eight tubes of different internal diameters mounted in a stand.
The stand illustrated is a valuable adjunct in the study of capillarity, in that it allows of view of a number of tubes at the same time, also affording convenient means for lantern projection. Finished in japan and gun-metal finish. Stand complete with eight tubes of different internal diameters **1.15**

20–145 **CAPILLARY TUBES,** consisting of four capillary tubes of different internal diameters connected to a water reservoir. For illustration see No. **20–150** . . . . . **.75**

20–150 **CAPILLARY TUBES AND SUPPORT** consisting of No. **20–145** Capillary Tubes, mounted on a neat cast-iron base. Base is provided with lacquered brass clips for holding glass part in place. Stand is handsomely finished in japan **1.22**

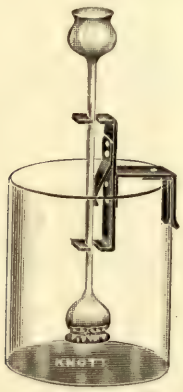
20–155 **CAPILLARY U-TUBE,** consisting of glass U-tube, one branch of which is a small capillary tube with white backing . . . . . **.33**

20–160 **CAPILLARY TUBES ON STAND,** consisting of ten U-tubes, one branch of each being capillary, and all of different internal diameters, mounted on support with scales for noting relative rise of liquid in the tubes. Duty Free **$6.15**

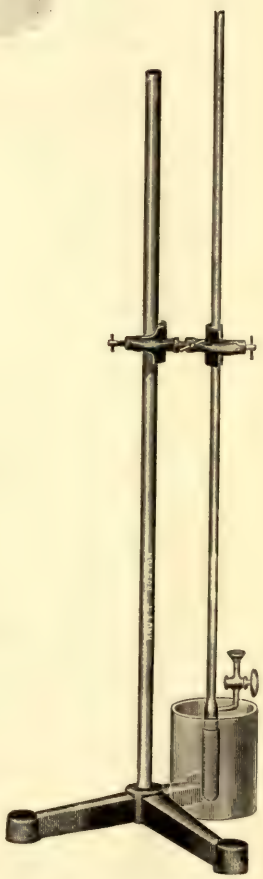


No. 20–160

No. 20–200



No. 20–215



No. 20–220

20–200 **ENDOSMOMETER** for illustrating the phenomena of Endosmose and Osmose.

The apparatus consists of a glass vessel the lower end of which is covered by a membrane, the upper end of which is connected to a glass tube which carries a scale. This vessel is supported so that the membrane is held under solution during examination.

All parts complete as illustrated **$3.70**

20–215 **STUDENTS' OSMOSIS APPARATUS** for qualitative as well as quantitative work in Osmosis.

The apparatus consists of an osmosis tube of design as illustrated, held adjustably in a nickel-plated clamp which may be clamped to the side of a jar. One end of the osmosis tube is closed by a thin porous membrane which may be removed and replaced from time to time as needed.

Apparatus complete as illustrated **1.25**

20–220 **OSMOSIS APPARATUS** after specifications by Thos. B. Freas of the Department of Chemistry, Columbia University, for illustrating the phenomenon of Osmotic Pressure.

This ingenious device consists of an S. & S. diffusion shell attached to a glass chamber which ends above in a heavy wall barometer tube 5 feet long. Entering this chamber is another tube with a funnel end and stop-cock through which the solution is allowed to flow.

For ease and rapidity of illustration this apparatus is unexcelled and the results are readily noticeable within fifteen minutes from the start.

Osmosis Tube with diffusion shell only without support of any kind **$3.90**

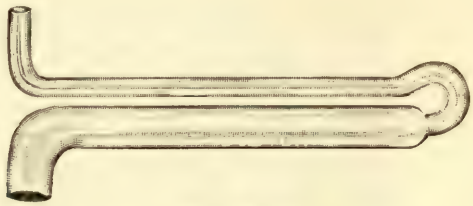
Articles illustrated in addition are:

22–130 **UNIVERSAL STAND** **2.00**

5–850 **UNIVERSAL RIGHT-ANGLE CLAMP** **1.05**

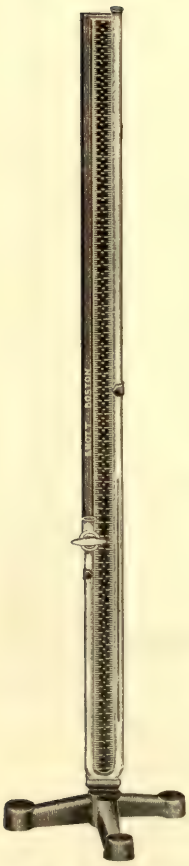
31–265c **BATTERY JAR,** 6 × 8 inches . . . . . **.40**

20–222 **DIFFUSION SHELL,** as used in above apparatus . . . . . Each **$0.35**; Per Ten **3.00**

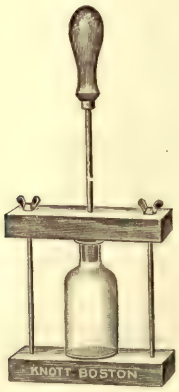


No. 20–230

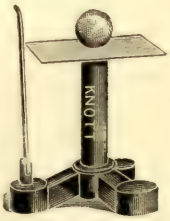
20–230 SCHIFF'S SURFACE TENSION APPARATUS, for the study of surface tension in liquids.
Consists of a special U-tube, one limb of which has large bore, the other capillary bore, bent at the top at right angles and with an enlargement just at the bend to prevent stoppage of the mouth of the tube by deposited drops **$1.10**



No. 20–250



No. 20–260



No. 20–270

20–250 INCOMPRESSIBILITY OF LIQUIDS APPARATUS, IMPROVED DESIGN, for the quantitative observation of the incompressibility of liquids.
This apparatus consists of a tube with indicating capillary. The liquid to be observed should fill the short arm of the tube and should rise in the long arm to near the top of the capillary. If mercury is poured into the long arm, the liquid, if compressible, will indicate the amount, if any, in the capillary.
Complete as illustrated, mounted on our No. **41–116** Boyle's Law Stand . . **$3.75**

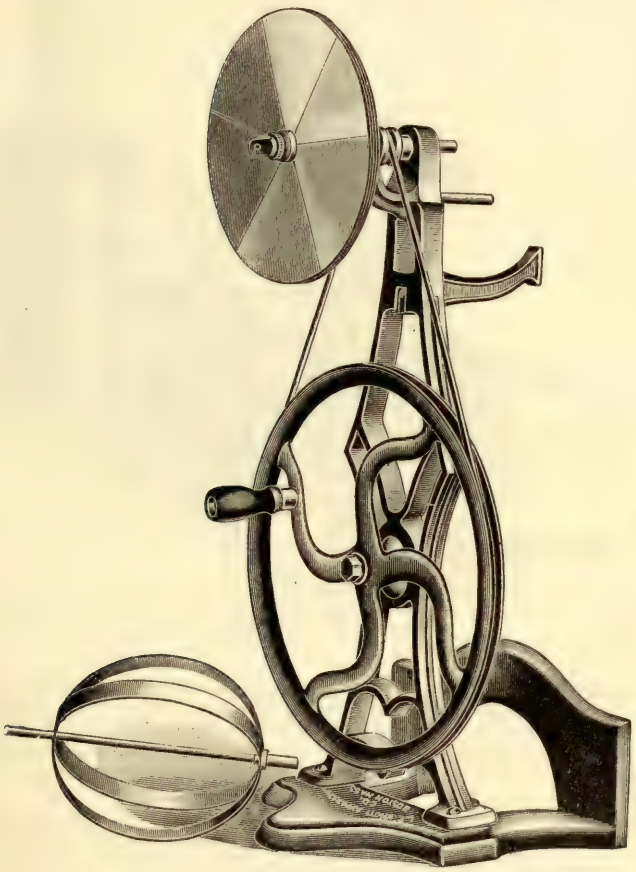
20–251 INCOMPRESSIBILITY OF LIQUIDS TUBE, only **2.50**

20–260 IMPENETRABILITY APPARATUS, illustrating the fact that two bodies cannot occupy the same space at the same time.
This apparatus consists of a frame which answers the double purpose of supporting the bottle and plunger and of a clamp. In use, the bottle is filled with the liquid, a one-hole rubber stopper placed in the neck, the end of the plunger placed in the hole and the bottle clamped firmly in place by means of the thumb nuts. If the plunger is now thrust into the bottle, the bottle will burst, demonstrating that two objects cannot occupy the same space at the same time, also, that a liquid is incompressible.
Complete, with three bottles **1.25**

20–270 INERTIA APPARATUS, for illustrative demonstration of Inertia.
The apparatus consists of a neatly finished base on which is mounted a nickel-plated rod with concave top. A metal spring fastened to the side of the base affords a device for giving the card illustrated a sudden blow on the edge, thus knocking the card from under the small ball showing that the ball does not change its position except as gravity causes it to drop into concave top when its prop is knocked from under.
Complete as illustrated . . . . . **.85**

CENTRIFUGAL FORCE

ROTATORS



No. 21–10

21–10 MECHANICAL ROTATOR OR WHIRLING TABLE for rotating objects to which it is desired to apply a centrifugal force.

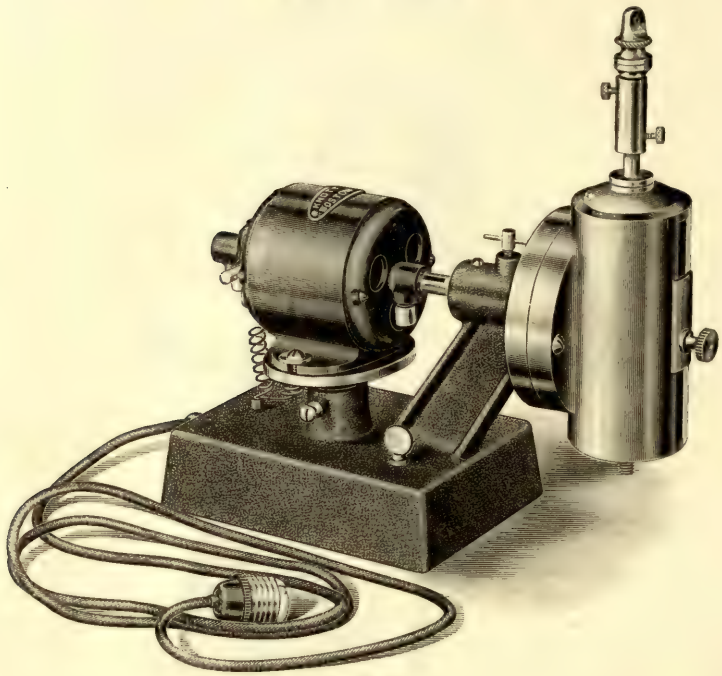
In the design of our Rotator we have observed closely all the scientific requirements of such an instrument. It is made of cast iron, all parts neatly japanned, and may be used in either a vertical or horizontal position. In design of our patterns we have placed the metal at points where the greatest stability may be secured. Furnished with each rotator are the various attachments for fastening the accessories. Thus there will be found with each instrument a universal chuck for fastening objects with a spindle; also a special lock-nut head designed for fastening plates, color discs, etc., and for attaching the string of such accessories as the Ring, Egg, and Chain.

Important features of this instrument are,—

1. Extreme rigidity, used in either vertical or horizontal position.
2. Large Drive Wheel, facilitating either high or low speed.
3. Handsome and durable finish.

Rotator only, without accessories also illustrated **$6.75**

THE UNIVERSAL SPEED AND POWER ROTATOR



Nos. 21–30 to 21–40

The motor rotator is desirable, if not essential, in Physical Laboratory demonstration, but the important problem of adequate power at low speed has not before been solved, two hundred revolutions being considered the low limit at which reasonable working power may be obtained.

We have, by the friction drive method, produced a **Universal Speed** and **Power Rotator** which runs without unnecessary friction and in which the power is **increased** as the speed is **diminished,** a feature which gives to it a breadth of usefulness not ordinarily looked for in these instruments.

While primarily designed for all of the usual whirling table experiments, it serves admirably as the power plant in **prony break tests** and in the **Mechanical Equivalent of Heat experiments** where the greatest smoothness as well as low speed and great power are required. When operated at high speed the outfit is particularly well adapted to the **energizing of gyroscopes** of high power.

FEATURES

UNIVERSAL POSITION. The countershaft housing, being designed so as to rotate through a complete circle, gives any desired position to the chuck holder.

A SPEED CONTROL which has never before been obtained in a rotator, from 0 to 4000 revolutions.

A METHOD OF REVERSING which is as simple as it is unique, carrying the shaft from the highest speed on one side gradually down to 0 and gradually up to the desired points on the other side, all without jar or shock, it being accomplished without touching a switch or reversing key.

POWER. Full power of the motor when the countershaft is running at the same speed as the motor and which **increases** in the same **ratio** as the **speed diminishes,** giving almost **unlimited torque** at very **low speed.** The crowning of the drive disc so as to insure greater contact pressure as the power is increased.

SAFETY. All parts enclosed so as to eliminate all danger from any moving portions of the instrument.

SPEED COUNTER. A direct connected speed counter attached to the countershaft, giving actual number of revolutions of the effective shaft. The counter may be thrown in or out of mesh at will.

UNIVERSAL CHUCK SOCKET. A chuck socket which readily takes all of the whirling table attachments requiring no wrench for adjustment.

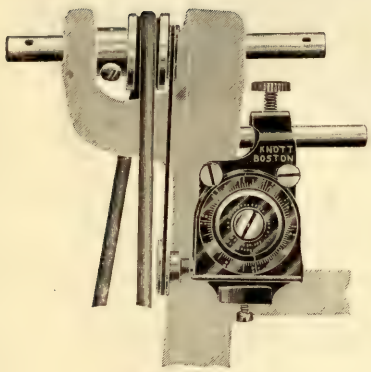
WEIGHT. The base of the instrument, a solid casting, supported by shock-absorbing points, stands firm and rigid on the lecture table, requiring no clamping.

VOLTAGE OF CURRENT

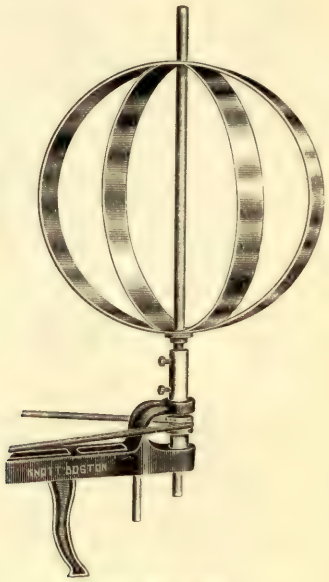
In ordering, specify the current for which the motor is desired: — 110 volt D. C., 110 volt, 60 cycles A. C., or battery current as desired. See listing below.

21–30	Rotator complete with Universal Chuck, for 110 volt D. C.	**$37.00**
21–35	Rotator complete with Universal Chuck, for 110 volt A. C.	**37.00**
21–40	Rotator complete with Universal Chuck, for Battery Current 6–8 volts	**39.00**

ROTATOR ACCESSORIES



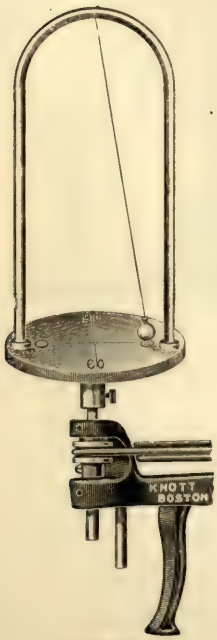
No. 21–50



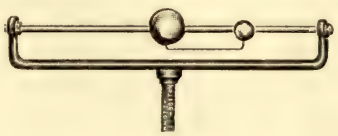
No. 21–60

21–50 SPEED INDICATOR for attachment to the Whirling Table when quantitative results are desired. This indicator is a high-grade instrument especially adapted to use on our Rotator. Illustration shows method of attachment to the Rotator **$4.15**

21–60 DOUBLE CENTRIFUGAL HOOP for illustrating the tendency of a semi-fluid body such as the Earth, to assume a flattening at the poles when rotating rapidly.
The apparatus consists of two flexible hoops of brass mounted on a central axis for attaching to the spindle of the Rotator **2.20**



No. 21–80

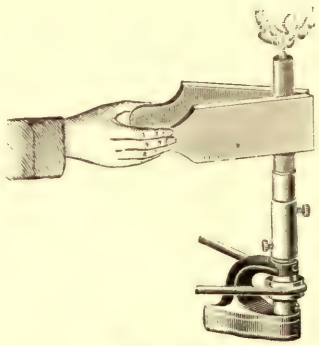


No. 21–100

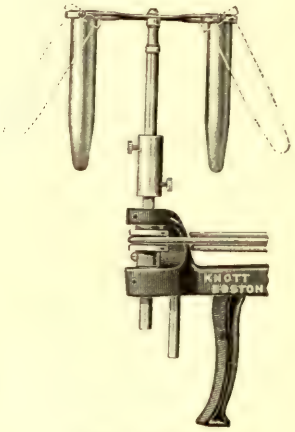
21–80 FOUCAULT'S PENDULUM for illustrating conservation of the plane of oscillation.
This design consists of a wooden disc, the under side of which is provided with an accurately centered spindle for attachment to rotator. The uprights support a pendulum, the point of suspension being directly over center of the disc.
In use, the pendulum is allowed to swing in the plane of the apparatus and then set slowly in rotation. The pendulum will maintain the course of its plane of vibration **$6.50**

21–100 CENTRIFUGAL FORCE APPARATUS, consisting of two connected balls of unequal mass mounted on a horizontal rod attached to a frame for connection to the Rotator **2.75**

No. 21–110



No. 21–120

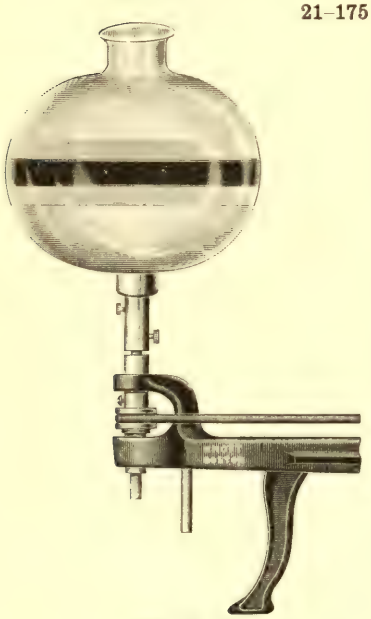


No. 21–150

21–110 CHAIN, EGG and DISC for illustrating the tendency of a body to rotate about its shortest diameter.
Consists of a Disc, a Chain and an Egg-shaped solid each with an attached cord for suspending to the head of the Rotator **$1.20**

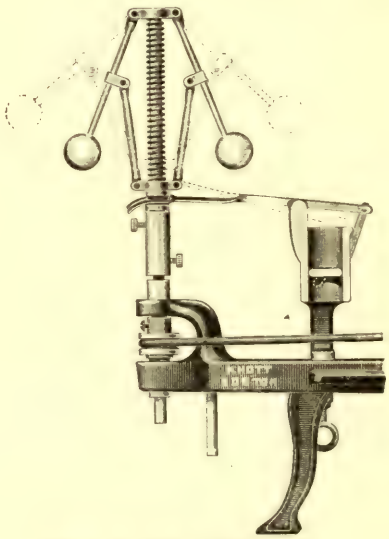
21–120 TYNDALL'S HEAT BY FRICTION ATTACHMENT for illustrating heat caused by friction on a brass tube while rotating rapidly.
Apparatus consists of a cylinder of brass attached to a rod for fastening to socket of rotator. If this cylinder is filled with alcohol and friction caused during rotation by means of the Friction Vise, it will be noted that the liquid is soon boiling.
Complete as described **2.00**

21–150 CENTRIFUGAL SEPARATOR for separating by centrifugal force solids held in suspension in a liquid.
The apparatus consists of a spindle with cross head. To the forked end of this cross head, brass collars are held in cone bearings. In these collars are placed the centrifuge tubes with their aluminum shields.
When rotated rapidly, solids held in suspension in a liquid contained in the tubes will gather at the bottom **3.70**



No. 21–175

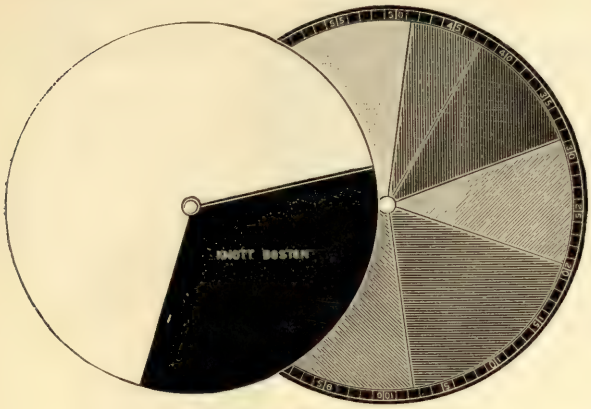
21–175 GLASS ROTATOR GLOBE for showing effect of rotation upon solids or liquids of unequal weight.
If three balls of same size but unequal weight or if two or more liquids of different specific gravity but which do not mix (mercury and water) are placed within the globe and the globe rotated, interesting and instructive phenomena will be noted.
This globe is of heavy glass and carefully balanced to rotate evenly. . . . **$2.85**



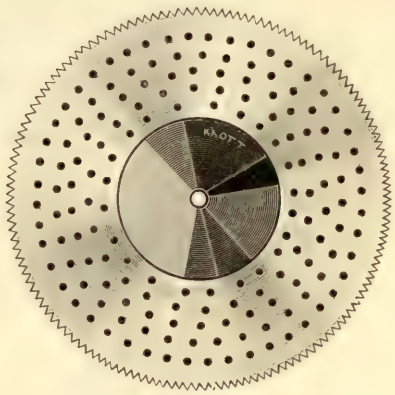
Nos. 21–185 and 21–190

21–185 WATT'S GOVERNOR for demonstrating the usefulness of a governor on an engine.
The apparatus consists of two metal balls suspended to two arms which in normal position hang downward, but pivoted so that in rotation they are free to rise and act against a spring.
Made of brass throughout and finished in lacquer and nickel **$4.50**

21–190 VALVE REGULATOR to be used in conjunction with above Watt's Governor in demonstrating the action of a governor in regulating the flow of steam into the steam chest of an engine.
Finished in bright japan with different parts colored for distinction at a distance from the lecture table **4.50**



No. 21–210



No. 21–220

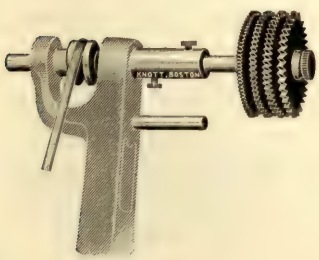
21–210 **COLOR DISCS** for quantitative work in color mixing and color analysis.

These discs are of heavy cardboard, 10 inches in diameter, with hole for attaching to spindle of Rotator. Each disc is slit that two or more colors may be combined, giving a disc of several colors 10 inches in diameter.

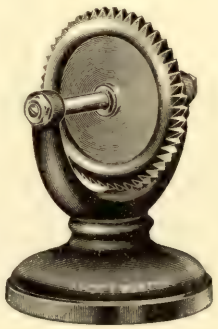
Set of discs of seven primary colors, one each of black and white, and a percentage circular protractor for quantitative work. **$2.00**

21–220 **COMBINATION NEWTON'S COLOR DISC, SIREN DISC** and **SAVART'S WHEEL** for showing white light when fixed portions of primary colors are rotated rapidly; and for demonstrating propagation of sound by mechanical disturbances which cause vibration in the surrounding media.

Consists of a heavy disc of metal with part of the face covered with colored segments of the seven primary colors in best proportions to show white when disc is rotated rapidly. Outside this colored portion there are drilled five rows of holes on concentric circles, four of which are evenly spaced and sound the tones C, E, G, and C′; while the fifth is unevenly spaced and sounds a harsh tone, — a noise. On the periphery of the disc are cut evenly spaced teeth . . . . . Each **3.90**



No. 21–240



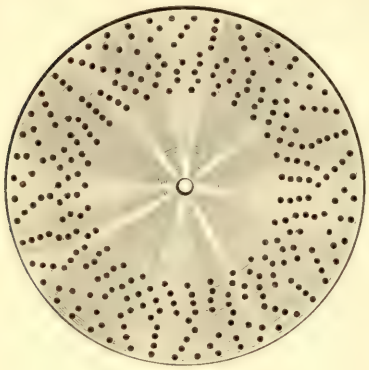
No. 21–245

21–240 **SAVART'S TOOTHED WHEEL** for demonstrating that tones are produced by regular impulses given to the surrounding medium.

Consists of four brass discs on the periphery of which are cut teeth, which, when touched by a card during rotation, will sound the tones of C, E, G, and C′. These discs are held fixed to a spindle for attaching to the socket of the Rotator. Finished in nickel throughout **$2.95**

21–242 ——, similar to above, but with only one wheel. For attachment to socket of the Rotator . . . . **.58**

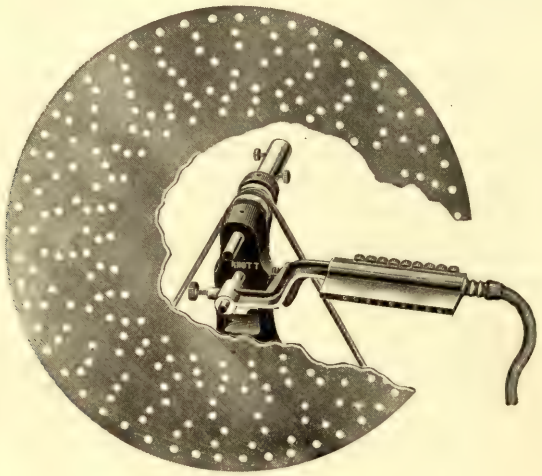
21–245 **SAVART'S TOOTHED WHEEL,** mounted on stand for string rotation. Consists of a heavy metal casting with teeth equally spaced on the periphery. This disc is mounted on axle and supported on a heavy casting. Durable japan and black oxidized finish **7.65**



No. 21–265

21–260 **SIREN DISC,** illustrating sound propagation by regular impulses given to the surrounding medium.
Consists of a 14-inch metal disc with five rows of holes in concentric circles, four of which rows have holes equally spaced to sound the tones C, E, G, and C′, while the fifth is unequally spaced to sound a "noise."
Disc is emery finished and nickel-plated **$1.90**

21–265 Same as above, but with nine rows of holes in concentric circles, eight of which are equally spaced to sound the scale of C, D, E, F, G, A, B, and C′, while the ninth is unequally spaced to sound a "noise." **3.15**



No. 21–270

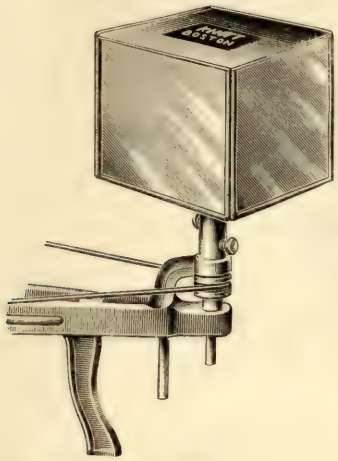
21–270 **AIR IMPULSE ATTACHMENT** for use with Siren Discs Nos. **21–220, 21–260,** and **21–265** for sounding by air impulses against the holes, one or more notes up to nine.
This instrument is an ingenious device provided with nine air valves, any or all of which may be opened by small thumb screws. It may be instantly adjusted to our Rotator. It is handsomely finished, positive in action and cannot get out of order. It is operated by blowing or by air bellows, requiring only a moderate blast. Attachment only **$2.95**

21–280 **CROVA'S DISC AND SHIELD** for illustrating compressional waves.
The apparatus consists of a disc, 11 inches in diameter, on the face of which are drawn progressively eccentric circles. When mounted so that a narrow strip of card only shows, a wave of alternate expansion and compression is clearly demonstrated.
Complete with Shield, as illustrated **$2.80**

21–280a **SHIELD** only **2.25**

21–280b **DISC** only . . . . . **.55**

No. 21–280



No. 21–290

No. 21–295

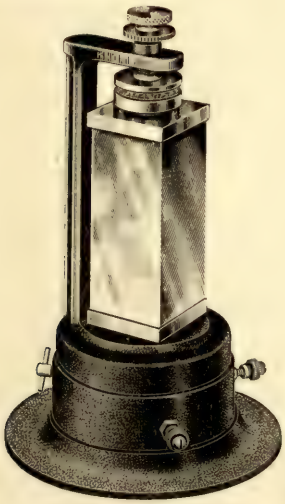
21–290 CUBICAL OR ROTATING MIRROR, for attachment to Rotator for study of reflection from a Rotating Mirror or for Manometric Flame images.

This design consists of four mirrors, one fastened firmly to each of the four vertical sides of a cubical box, to the under side of which is attached an accurately centered spindle for fastening to socket of rotator. All parts finished dead black **$3.15**

21–295 KOENIG'S MANOMETRIC FLAME CAPSULE for transmitting the motion of sound waves to gas flame, which by their pulsations indicate the nature of sound.

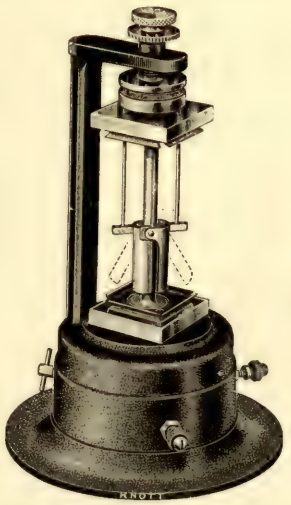
This design consists of two metal castings, between which is sealed a membrane. One casting is provided with jet, other with mouth-piece and connecting tubing. The whole is mounted on a gas tube attached to a substantial metal base.

Complete as illustrated **3.20**



No. 21–300

Patent Pending

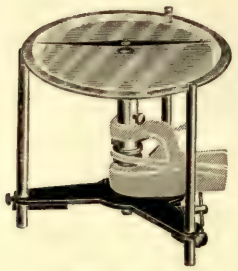


No. 21–300 (Sectional View)

21–300 REVOLVING MIRROR, WITH POSITIVE SPEED GOVERNOR. To meet the repeated demands for a mirror which may be revolved at varying speed and of a size sufficiently large for ordinary laboratory work we have, after considerable experimentation, devised the above illustrated method.

This mirror is self-contained in that the power is contained in the base in the form of a battery motor, with "start" and "stop" key. We secure a positive speed, governed by means of a simple, effectively operating device noted above the mirror shaft. We are able to secure with this device speeds varying from a few revolutions per minute up to 4000, the maximum speed of the motor. This variation in speed may be made during the revolution of the mirror simply by a movement of the milled screw over the axle.

As may be noted this design consists of a metal housing which serves also as a substantial base. Cast to this housing is an upright with projecting arm. The mirror is mounted in metal castings carefully centered. The metal housing is provided with binding posts for connections to the motor and also with "start" and "stop" key. The whole is finished in nickel and black oxidized, presenting a handsome appearance. It will be found efficient for all general work for which a rotating mirror is used **$8.75**



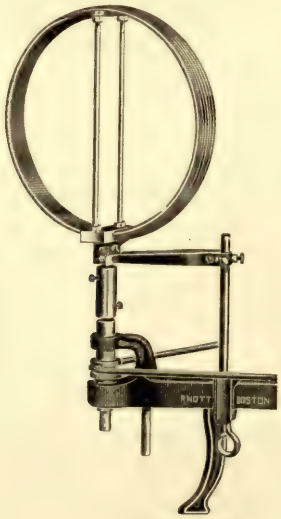
No. 21–305

21–305 ARAGO'S MAGNETIC ROTATION APPARATUS, for demonstrating the reaction between the electric currents induced in a rotating copper disc and a magnet, illustrating, also, the damping effect of copper upon a magnetic needle.

The apparatus consists of a metal casting which may be attached to our rotator as illustrated, and which carries adjustable arms for supporting a clear glass plate with beveled edges. Fastened at the center of this glass plate is a small support for the Magnetic Needle. The apparatus is finished in lacquered brass and bright japan.

As the copper disc is rotated, the Magnetic Needle is deflected in the direction of the rotation, and if the speed is fairly great, the needle will be dragged completely around so that it is set in rotation. When the rotation is stopped the damping effect of the copper is strikingly noticed.

Apparatus complete as illustrated, ready for attachment to our rotator **$6.15**



No. 21–310

21–310 EARTH INDUCTION APPARATUS, for mounting to the socket of a rotator to illustrate induced currents set up in a coil of wire by the inductive action of the earth.

This apparatus consists of a closed coil of wire wound on metallic frame, provided with commutator and brushes, ready for attachment to a rotator **$7.10**

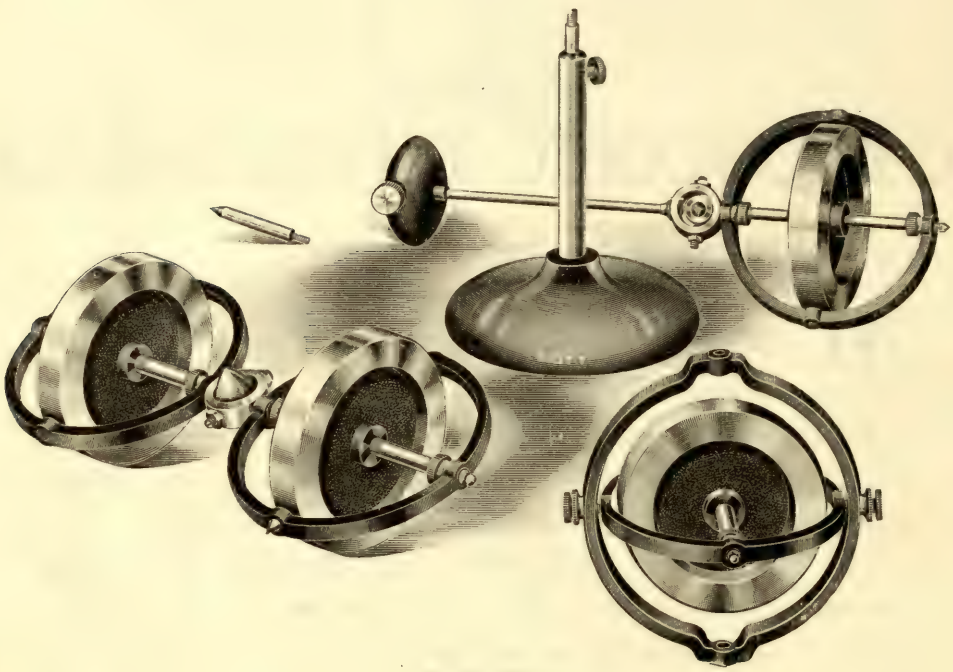
GYROSCOPIC PHENOMENA

MUCH interest is sustained in Gyroscopic Phenomena from the growing practical application of Gyroscopic forces. These forces are variously used in mono-rail locomotion, and much interest has been aroused by the recent practical uses in England and Germany as well as in our own country. Its use as a corrective force on a ship's compass has been frequently employed. Germany has used, with success, Gyroscopes in obviating the roll of ships. Many other interesting applications could be outlined; and it has not seemed out of place for us to list at this point a number of accurate instruments illustrating the principle which has been used in the practical applications.

21–335 "SPINNING TOPS." By Prof. Perry. Per copy **$1.25**

For those who wish to investigate or understand Gyroscopic action, we strongly recommend "Spinning Tops," by Prof. Perry, who, in a very simple and interesting manner, describes and explains many interesting experiments, much of the apparatus for which will be found in the following pages.

THE HARCOURT UNIVERSAL GYROSCOPE



No. 21–340
Patent Pending

It is with much satisfaction that we list here this valuable series of instruments for demonstrating gyroscopic phenomena.

The plan on which these instruments are designed is that of using the simple unit to demonstrate the simpler forms of gyroscopic action and to build up from this unit a complete line of accurate and well-worked-out gyroscopes.

If it is not possible to purchase the complete outfit at once, the simple element with stand may be purchased at first, and other features added at will until the complete system is obtained. By this plan, a full set of gyroscopes may be obtained at much less cost than the separate instruments.

THE BASIC UNIT. This consists of a perfectly balanced wheel 3½ inches in diameter, so designed that the mass is kept as near the periphery as possible.

DETAILED FEATURES

LOCK-NUT on Basic Unit. The method of holding the wheel in its gimbal ring is unique, in that the lock-nut is so placed that it serves to prevent the power string from catching in the bearing when in use.

UNIVERSAL BEARING POST. A convenient and well-designed reversible bearing post is fitted to the base standard. It serves the multiple purpose of providing a suitable pivotal bearing, a thread post for attaching any of the rings, and a cup support for the ball-bearing on the end of the main axle.

UNIVERSAL GIMBAL BEARING. A valuable adaptation of the gimbal bearing worked out by E. S. Ritchie, to give the greatest freedom of motion with the least friction. The use of this bearing is well illustrated in the building up of both the **COUNTERPOISED** and the **BOHNENBERGER** type of instrument.

It will thus be seen that from the basic unit, by the addition of accessory parts, we are able to assemble all forms illustrated below. For example: —

In order to assemble the Gyroscope No. **21–360,** use the Supporting Stand with Universal Cone and Cup Bearing and the Basic Unit.

To assemble the **COUNTERPOISE GYROSCOPE,** No. **21–355,** the only additional parts would be the Extension Rod and Counterpoise, together with the Gimbal Bearing, if desired.

To assemble the **BOHNENBERGER GYROSCOPE,** No. **21–350,** only the Bohnenberger Ring need be provided in addition to the above.

The **COMPOUND GYROSCOPE,** No. **21–345,** requires one extra Basic Unit.

It will thus be seen that the cost of the Gyroscopic Outfit in this form will be much less than the price of the individual instruments furnished complete. This is our reason for strongly advising the purchase of one complete outfit, if possible.

The various parts going to make up the complete outfit may be briefly stated as follows:

1 STAND, UNIVERSAL ROD with Cone and Cup Bearings.
2 ROTATING WHEEL SYSTEMS (BASIC UNITS).
1 EXTENSION ROD WITH COUNTERPOISE.
1 GIMBAL RING AND BEARING.
1 BOHNENBERGER RING AND BEARING.

21–340 GYROSCOPIC OUTFIT complete as above listed **$17.45**

NOTE. — Great care is exercised in testing out all of the parts with their interchangeable features before the instruments are shipped.

21–345

21–345 FESSEL'S COMPOUND GYROSCOPE. This Gyroscope consists of two of the Basic Units described on the preceding page, mounted on stand as illustrated. We desire to call attention to the fact that with the purchase of this Compound Gyroscope, simple gyroscopic action as illustrated under No. **21–360** may be demonstrated by dissembling the Compound Gyroscope and using the parts as illustrated **11.00**

21–350 BOHNENBERGER'S GYROSCOPE. This Gyroscope, as may be readily noted, consists of our Basic Unit with the addition of the Bohnenberger Ring and Bearing. It will be noted, also, that this Gyroscope may be dissembled and used in demonstrating simple gyroscopic phenomena as illustrated under No. **21–360** **$8.75**

No. 21-350

21–355

21–355 COUNTERPOISE GYROSCOPE, assembled as illustrated from the Simple Gyroscope Basic Unit, Extension Rod and Counterpoise, Gimbal Ring and Bearing, and mounted on a Stand with Universal Bearing Post **7.50**

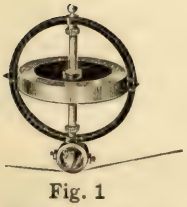


Fig. 1

No. 21–360

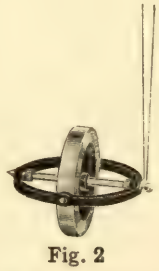
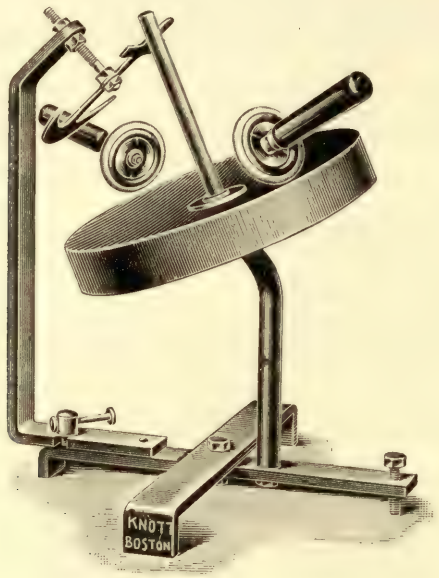


Fig. 2

21–360 SIMPLE GYROSCOPE, 3½ inch wheel. This instrument is not a toy, although the illustrations depict its use in positions as so frequently advertised by toy manufacturers. Under this number, we supply the Simple Gyroscope Basic Unit with Supporting Stand and Universal Bearing Post. Perhaps no single instrument is capable of such spectacular results as that of the Simple Gyroscope, and every school equipment should have at least one, constructed scientifically and sufficiently massive to place it in the realm of scientific instruments **$5.50**



No. 21–365

21–365 WOODEN GYROSCOPE TOP for illustrating the effect upon a rotating disc by altering the plane of rotation; also for illustrating the effect due to tilting pressure.

This top, which has a diameter of 16 inches, is made to spin on a bicycle ball-bearing by rolling the handle between the palms of the hands. If, when spinning, the axis or handle of the top is allowed to touch the anchor shaped piece of iron, it will run along the edge of the iron pressing hard against it all the time, and thus constantly altering the plane of rotation of the spinning disc.

In order to illustrate the effect due to a tilting pressure, unscrew the capstan head which clamps the upright carrying the anchor, swing the upright to one side and remove it. Spin the top by rolling the handle between the palms of the hands. If pressure is now applied to a point on the top surface near the edge of the disc one would expect the top to tilt and continue to spin at an angle, but it is not the part of the top's disc that is being pressed that goes down, but a point at an angle of 90 degrees from it in the direction in which the top is spinning, while at the same time the opposite side of the disc rises to a corresponding extent.

That the pressure may be applied with as little friction as possible so as not to stop the spinning of the top, a pair of handles with rubber edged friction rollers are supplied. By pressing alternately with these on opposite sides, the curious see-saw motion is readily seen while it will be noticed that neither of the points at which the pressure is applied can be made to move either up or down.

This top is made large so that it may be seen by a large audience and it is especially suited to lecture table work. It is mounted upon a four-footed base, one of the feet of which is provided with a leveling screw which, when screwed down to just touch the table, causes the base to stand firmly on an uneven surface.

Apparatus complete as illustrated with Anchor Plate, Upright Support and two Handles with Friction Rollers . . . . . Duty Free **$38.50**

No. 21–370

21–370 STILT GYROSCOPE, for illustrating the resistance exerted by a spinning gyroscope in the mono-rail to wind pressure, causing the whole carriage to lean over towards the wind and to lean more and to increase its resistance in exactly the same ratio as the force of the wind increases.

The apparatus consists of an accurately balanced gyroscope mounted in a frame on cone bearings at the top of two pointed stilt-like supports.

To show this experiment successfully it is necessary to spin the top very fast, which can be accomplished by a string in the ordinary way, or some may find it easier to use the Gyroscope Spinner No. **21–373** which is a far more efficient method of spinning ordinary gyroscopes than the ordinary way of using a piece of string. Of course, until it is spun the top will not stand upright, but when spinning fast it even resists being knocked down and stands firmly on its two points if placed in the position illustrated. When in this position, the top will slowly rotate on its axis, and if it goes so far that the spinning disc stands nearly or quite at right angles to the position shown in the illustration, it will fall down, as in doing so it no longer has to alter the plane of rotation of the spinning disc and so the latter exerts no force to keep it up. If, however, as soon as it begins to rotate on its vertical axis it is very lightly tapped on the wing with a pencil in the same direction, as if to assist it in its movement, it will at once come back to its former position, and so effective is this that it can be kept standing upright on the stilts by gently touching or tapping one side or the other as may be required until the top has nearly run down. This illustrates well how in the mono-rail the carriage is kept upright although the center of gravity is far above the point of suspension. In the top, the point of suspension is of course the two knife edges at the bottom of the stilts, while the center of gravity is slightly below the axis of the spinning disc. This is a most interesting and striking experiment.

STILT GYROSCOPE, complete as illustrated . . . . . Duty Free **$18.00**

21–373 GYROSCOPE SPINNER, for obtaining speed of rotation on any Gyroscope Wheel.

The apparatus consists of a cast iron base on which is mounted a series of gears which are operated by means of a crank which in turn operate upon a wooden disc the rim of which is covered with rubber.

In use the Gyroscopic Wheel is held against the rim of the disc and as the crank is turned the wheel gets up speed which is increased as the handle is turned faster and faster.

Gyroscope Spinner with Clamp for attaching to the table . . . . . Duty Free **13.25**

No. 21–390

No. 21–390 (Illustrating Figures)

21–390 GEOMETRIC GYROSCOPE TOP for illustrating Stability Due to Rotation, the Precession of the Equinoxes and the Nutation of the Earth's Axis.

The apparatus consists of a base with upright having a curved arm drilled and provided with a set screw. Directly beneath this hole on the base is a steel cup into which fits the point at the end of the axle of an accurately turned Gyroscopic Top. Into this hole may be placed the rod having the various geometric figures which may be obtained. As a further feature of the top it is made with an adjustable axis so that the point on which it spins may be fixed above or below or exactly to coincide with the center of gravity of the top. Interesting results are possible with this adjustable feature.

To illustrate rotary stability the brass geometric figure shown in the illustration is removed, and the top simply placed with its point in the steel cup. Now, without spinning it, try to place its axis in various positions, either vertical or inclined, and it will be found that the top will not remain as it is placed; but spin the top slightly with the fingers, and as long as the rotation continues the axis can be placed vertical, or at any inclination, and will maintain its own position. So much is this the case that if the top be so spun that the rotation is rapid, it will be found to require some force to make it change its inclination.

Fix the geometric figure in its place so that the side of the upper portion of the steel axis rests against it. If the top be now spun it will be found that directly its axis touches the figure it will follow the shape of it, moving round curves and angles with great facility. This motion is similar to that of a cart wheel moving along a road, the rotating axis acting as the wheel and the figure as the road; but the motion would cease if the axis were not kept in its position, touching the figure, by the stability imparted to the top by its rapid rotation.

The stability or disinclination of the rotating axis to alter its position is so powerful that some of the geometric figures will be seen to bend slightly under the strain, even when the top is simply spun by the fingers, and if spun rapidly by means of a string probably they would be twisted out of shape, simply by the disinclination of the top to change its plane of rotation.

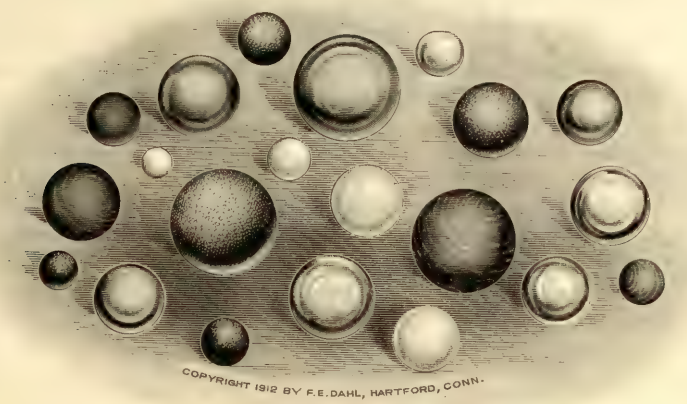
To illustrate the Precession of the Equinoxes, remove the geometric figure and spin the top in its steel cup. The axis can now be slightly inclined, and the stability already explained will cause it to remain inclined as long as rapid rotation is kept up. But by observing the top of the axis carefully it will be found to be slowly revolving in a circle. This is exactly what the axis of the earth is doing, producing what is technically known as the Precession of the Equinoxes, only the top completes the circle in a few moments, whereas the earth takes about 26,000 years to perform the same operation.

To illustrate the Nutation of the Earth's Axis, it is only necessary to call the attention to the circular motion of the axis in the above experiment and to further note that the upper point of the axis is also describing tiny circles around the circumference of the large circle. This very effectively illustrates the motion called in Astronomy the Nutation of the Earth's Axis.

Apparatus complete, as illustrated, with three figures . . . . . Duty Free **$14.50**

ACTION AND REACTION

BALLS



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Nos. 22–10 to 22–110

PENDULUM BALLS, for use also in Action and Reaction Experiments.

22–10 WOODEN BALLS:

	a	b	c	d
Diameter, inches	¾	1	1½	2
Price	$0.06	$0.10	$0.12	$0.16

22–20 GLASS BALLS:

	a	b	c
Diameter, inches	¾	1	1½
Price	$0.05	$0.15	$0.35

22–30 IVORY BALLS, accurately turned, polished, and with a hole drilled for suspension:

	a	b	c
Diameter, inches	1	1½	2
Price	$1.60	$1.90	$2.50

22–40 LEAD BALLS, made of cast metal, drilled for suspension:

	a	b	c	d
Diameter, inches	⅝	¾	1	1½
Price	$0.05	$0.09	$0.16	$0.54

22–50 BRASS BALLS, accurately turned, polished, drilled for suspension:

	a	b	c	d
Diameter, inches	½	¾	1	1½
Price	$0.12	$0.17	$0.30	$0.78

22–60 IRON BALLS, cast, drilled for suspension:

	a	b	c	d	e
Diameter, inches	¾	1	1½	2	3
Price	$0.06	$0.07	$0.13	$0.30	$0.50

22–70 STEEL BALLS, hardened, accurately ground and polished. There are no holes, but the small balls may be suspended by shellacing a thread to them.

	a	b	c	d	e	f
Diameter, inches	⅜	½	¾	1	1½	2
Price	$0.04	$0.06	$0.09	$0.20	$0.52	$1.65

22–72 STEEL BALLS, with loop attachment for suspension, 1 inch diameter **$0.50**

22–80 LIGNUM-VITAE BALLS, 1½ inches in diameter . . . . . **.30**

22–90 COPPER BALLS, not turned but drilled for suspension:

	a	b	c
Diameter, inches	¾	1	1½
Price	$0.27	$0.42	$0.85

22–100 CORK BALLS, lathe turned, and drilled for suspension:

	a	b	c
Diameter, inches	¾	1	1½
Price	$0.06	$0.10	$0.20

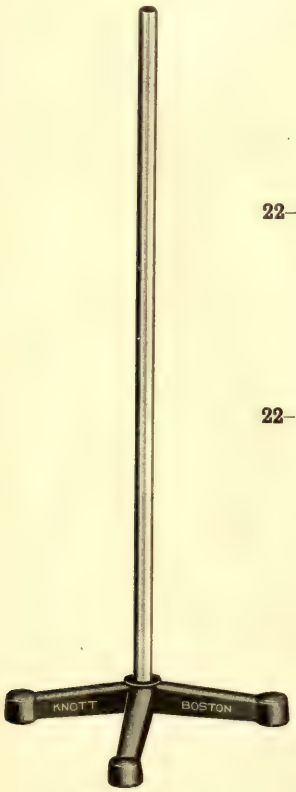
22–110 COMBINATION SET OF BALLS, for use in collision experiments, giving a variety of weights with approximately the same size. The set consists of a 1½ inch ball of cork, ivory, lignum-vitae, glass, iron, brass, copper and lead . . . . . Set **4.90**

ACTION AND REACTION

IMPACT SECOND LAW OF MOTION

It will be noted from this point on, that frequent use is made of a Support Rod mounted on a Tripod Base. We desire to call attention to the extreme utility of this stand. Besides forming a rigid support for various accessories illustrative of the Laws of Mechanics under discussion, it presents a handsome appearance and will support practically all of our accessories illustrated in the following pages.

In this place, we also desire to call attention to the fact that we have wherever practical, discarded wood supports, using in all our designs special castings made from expensive patterns. This line, therefore, will be found practically indestructible. It is scientific in appearance and any laboratory may well be proud of a thorough equipment. Each casting is uniformly smooth and appropriately finished. Wherever a clamp is a part of the casting, the screw is heavily nickel-plated.



No. 22–130

22–130 UNIVERSAL STAND. From the illustration herewith, and from the many following illustrations where a rod is shown, it will be noted that this stand is practically indispensable. It consists of our No. **5–20e** Support Rod, 100 centimeters long, 19 millimeters diameter, and our No. **5–155** Tripod Base.

We list it herewith as a unit, that we may emphasize its extreme utility.

Complete as illustrated **$2.00**

22–131 UNIVERSAL STAND, same as above, but tripod provided with three leveling screws **3.00**

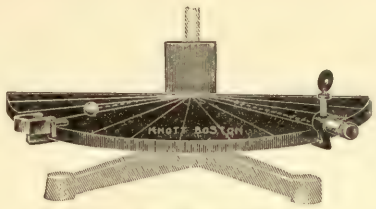
22–135 IMPACT APPARATUS, illustrating by impact of equal masses the resolution of one force into two equal forces.

The apparatus consists of a casting with clamp for attaching to our Universal Support No. **22–130.** This casting is provided with friction taper plugs for holding the balls of equal masses in bi-filar suspensions. At rest, the lengths of these suspensions should be adjusted so that the balls just touch each other.

By impact of one ball simultaneously against the other two, it will be noted that each of the impinged balls are forced a distance equal to half that which the impinged ball traversed.

Complete as illustrated, ready for attachment to rod of Universal Stand . . . **$2.90**

No. 22-135



No. 22–145

22–145 IMPACT AND REFLECTION ATTACHMENT for determining the laws of impact, also for determining law for incidence and reflection of light.

This attachment consists of a special clamp casting to which is firmly fastened the graduated half-circle disc of wood. As a part of this casting, is an impact plate and "boss." To the latter is swiveled two arms, one of which is equipped with a spring gun, designed to project a ball against the impact plate, the other with stop for receiving ball after rebound from impact plate.

By setting the arm carrying the spring gun at some position and projecting the ball against the plate, it will be found that the stop will have to be moved to a similar position on the other side of the normal line.

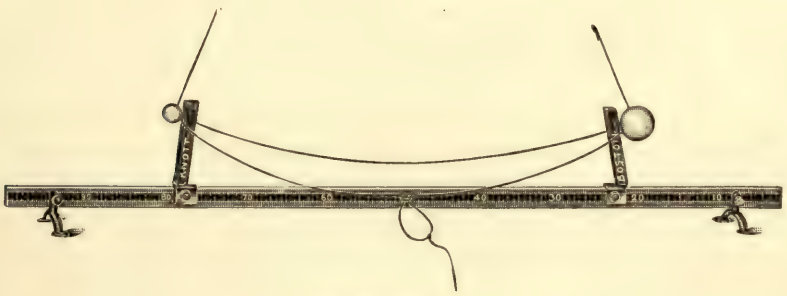
A simple attachment making this apparatus of greater utility is provided on the spring gun arm. This consists of an upright with sight hole. If a lighted candle is placed in the stop, which is designed for this double purpose, and a mirror attached to the impact plate, it will be found that the sight hole will have to be moved to a similar position on the other side of the normal to receive the reflection of the candle.

Attachment complete as illustrated, with the addition of a Mirror for determining the law of incidence and reflection of light **$6.65**

NOTE. ACCESSORY APPARATUS NEEDED

22–130 UNIVERSAL SUPPORT **$2.00**

CANDLES. See Index.



No. 22–160

22–160 ACTION AND REACTION APPARATUS for quantitative demonstration that Action is equal but opposite to Reaction when two elastic bodies impinge.

The apparatus consists of a mounted Meter Stick on which are placed and clamped, where desired, two ingenious detents. Two ivory balls suspended from any convenient hanger rest against these detents and are released by a sudden pull on a string which drops the detents, thus allowing the balls to fall towards each other starting at the same instant.

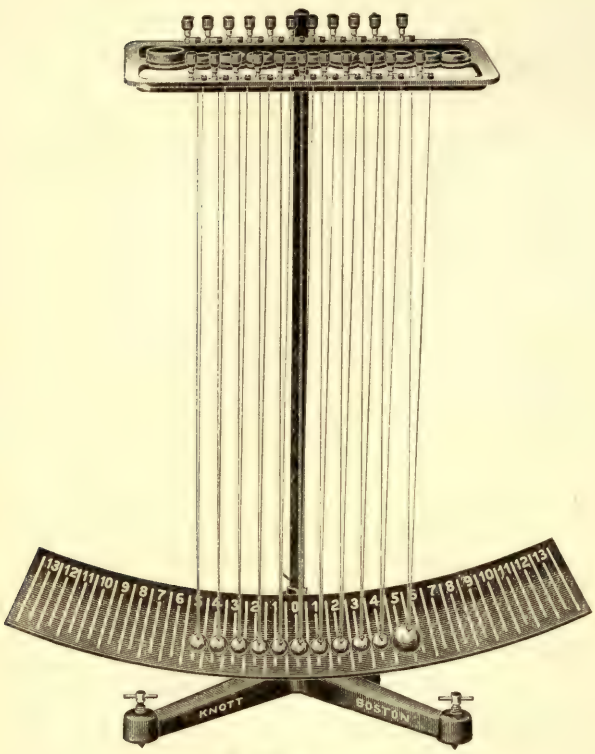
Complete apparatus as listed separately below **$5.50**

22–160a METER STICK, with loop for string . . . . . **.33**

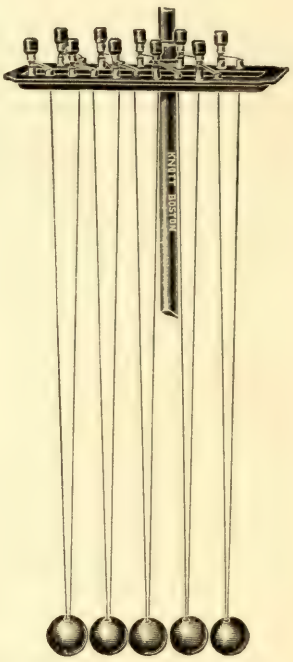
22–160b METAL SUPPORTS for Meter Stick . . . . . Per Pair **.25**

22–160c DETENTS ready for attachment to Meter Stick . . . . . Per Pair **.60**

22–160d IVORY BALLS, two of different masses . . . . . Per Pair **4.40**



No. 22–180



No. 22–190

COLLISION BALL APPARATUS, IMPROVED FORM, for the quantitative and qualitative study of impinging elastic bodies.

The apparatus consists of a rectangular metal frame of special design for attachment to our Universal Stand No. **22–131**. Ten steel balls, 1 inch in diameter and one steel ball four times the mass of each of the others are attached to this frame by stout silk cords and held adjustably to it by tapering plugs. As each ball is held in a bi-filar suspension, the directive force of impact is at the will of the operator simply by turning the tapering plugs. A special design graduated arc is necessary for quantitative work. This arc is made to attach directly to the Universal Stand No. **22–131.** The lines and figures being especially clear, they may be seen from the rear of any lecture room.

22–180 **COLLISION BALL APPARATUS,** complete with No. **22–131** Universal Stand, Rectangular Attachment with ten steel balls, 1 inch in diameter, and one steel ball of four times the mass of each of the others, and with Graduated Arc with Clamp for attachment to the Universal Stand . . . **$14.75**

22–181 **RECTANGULAR FRAME** with Clamp, including all balls, listed above **9.85**

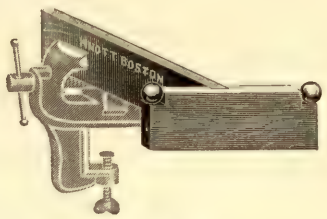
22–182 **GRADUATED ARC** with **CLAMP** as used in No. **22–180** **2.60**

22–131 **UNIVERSAL STAND** **3.00**

22–190 **COLLISION BALL APPARATUS** for study of impinging elastic bodies.
This apparatus consists of a rectangular frame similar in general construction to that used above but designed for suspending five lignum-vitae balls, each in bi-filar suspension. The apparatus illustrated is designed to clamp over any 19 millimeter rod.

Rectangular Frame with the five balls attached **3.85**

No. 22–200



No. 22–220

No. 22–225

22–200 MOMENTUM APPARATUS for deriving laws of momentum.
This apparatus is designed for attachment to our Universal Support No. **22–131**. It consists of a rectangular metal frame supporting in bi-filar suspension two bodies with masses of the ratio 1: 4. The larger body has a special ingenious spring striking attachment operative on both bodies at the same time. In operation, this striking attachment is pulled back against the spring and held by a piece of string. When this string is burned a blow is given to the smaller body which is communicated to the larger at the same time.
The complete apparatus consists of the Rectangular Frame Momentum Attachment, the Universal Support No. **22–131** and a Graduated Arc. Complete apparatus **$11.00**

22–201 MOMENTUM ATTACHMENT only **5.65**

22–182 GRADUATED ARC WITH CLAMP for attachment to a 19 millimeter rod **2.60**

22–220 SECOND LAW OF MOTION APPARATUS consisting of a flexible hardwood strip about 15 inches long and a vise for attaching one end firmly. The hardwood strip has a right angle head with a notch at each upper end in which are placed small marbles.
In use, the marbles are placed in position in their respective notches, the flexible strip is then bent to one side and released. One marble will shoot out horizontally, while the other, owing to its inertia, will drop automatically at the same instant taking the course of a straight line, thus demonstrating the Second Law of Motion.
Complete with Vise **1.45**

22–221 BENCH VISE CLAMP as used in No. **22–220** **1.00**

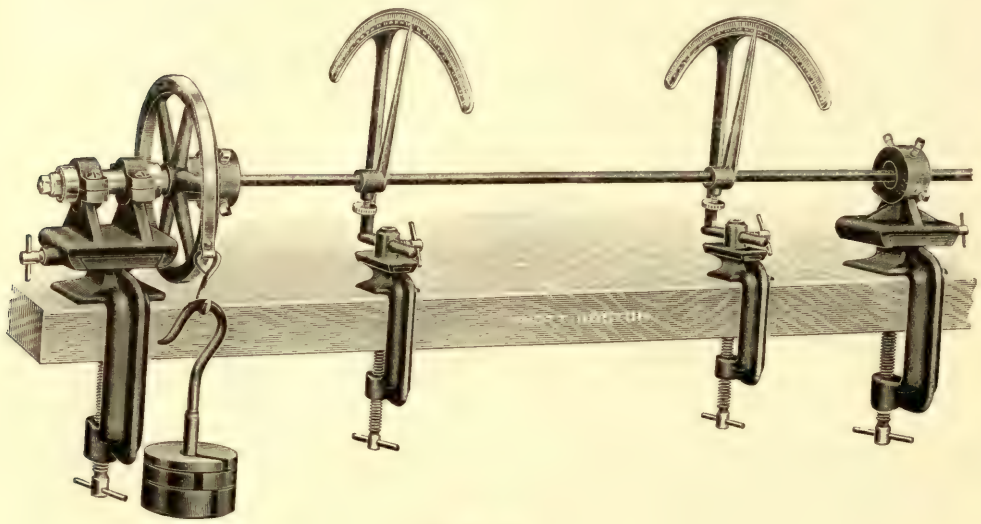
22–222 FLEXIBLE HARDWOOD STRIP as used in No. **22–220** . . . . . **.45**

22–225 SECOND LAW OF MOTION APPARATUS. This design above illustrated is one simplified for use in the hand. The length of the rod is such that when rod and attached ball are pulled against the spring and then allowed to be propelled from the tube, the second ball will drop from the rod at the same instant as the ball and rod leave the tube, they both reaching the floor at the same instant, although one drops in a plumb line and the other describes a parabolic path **2.90**

22–230 GAGE'S SECOND LAW OF MOTION APPARATUS.
This apparatus consists of a metal casting holding a rod actuated by a spring. Two spheres are provided, one solid while the other is drilled for slipping over one end of the rod when the spring is held back for releasement. The solid sphere is placed in position as illustrated so that when the spring is released the end of the rod will inflict a blow upon it, shooting it out in a horizontal position. The rod is of such length that when the spring is released the drilled ball will drop at the same time as the solid ball receives its blow. It will be observed that the solid ball describes a parabola while the drilled ball drops in a plumb line, both reaching the floor at the same instant.
In use this apparatus should be firmly attached to a heavy wooden block or to a table top **3.15**

STRESS AND STRAIN

TORSION OF BEAMS TORSION OF WIRES ROTATIONAL VIBRATION FLEXURE OF BEAMS YOUNG'S MODULUS TENSILE STRENGTH OF WIRES



No. 23–10

23–10 HARCOURT T-BEAM TORSION APPARATUS for determining the moment of torsion and the coefficient of torsional rigidity of rods of different lengths and different diameters. The above illustration shows the adaptability and interchangeability of our Universal T-Beam Series. (Section **5**).

The distinctive torsion parts consist of a ball-bearing Torsion Wheel (No. **5–1175**) in the hub of which the movable end of the rod may be centered and rigidly fixed by set screws. The other end of this rod is firmly fastened in a similar manner in the Fixed Head Torsion of Beams Attachment (No. **5–1180**). The twist on the rod so fastened is secured by weights attached to a steel ribbon wound about the flat face of the torsion wheel. The length of the rod under experimentation may be arbitrarily determined by the positions of the Index Arcs and Pointers; the former secured by movement of the clamp on the table; the latter by movement of the Pointers along the rod. The Index Arcs have interlocking attachment for use on our T-Beam Basic Clamp "A." The Pointers are fastened to the rod by set screws.

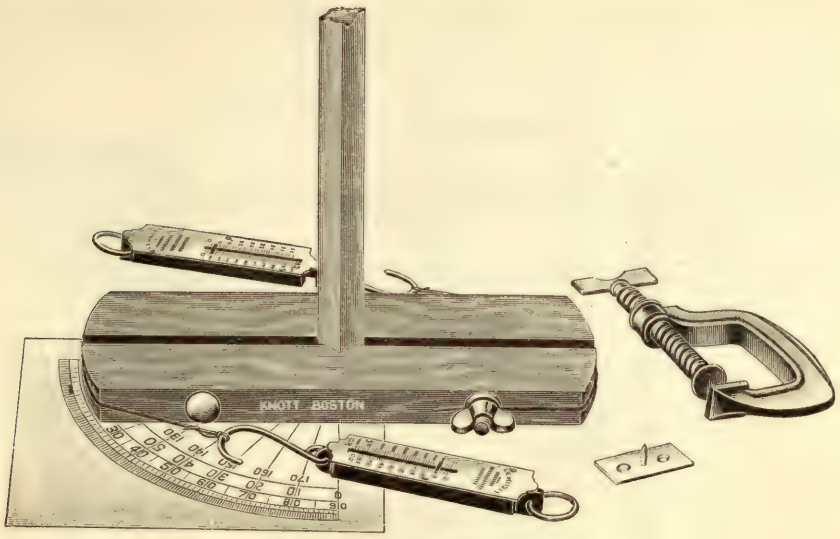
Complete apparatus without clamps and without hanger and weights **$9.15**

The Basic Clamps used in above illustration are:

5–1000 T-BEAM BASIC CLAMP "A" (two required) . . Each **$1.15**

5–1150 T-BEAM BASIC CLAMP "B" (two required) . . Each **1.90**

WEIGHTS Section **16.**



No. 23–30

23–30 SIMPLE TORSION APPARATUS for deriving laws of torsion.
Complete apparatus, as listed below, including two spring balances **$2.50**

23–30a ASH ROD, ½ × ½ inch . . . . . **.12**

23–30b ASH ROD, ¾ × ¾ inch . . . . . **.14**

23–30c COMBINATION BASE LEVER . . . . . **.60**

23–30d GUIDE PIVOT . . . . . **.25**

23–30e IRON CLAMP FOR ROD . . . . . **.35**

14–45 QUARTER CIRCLE PROTRACTOR . . . . . **.16**

15–310 SPRING BALANCE . . . . . **.45**

No. 23–50

23–50 IMPROVED SABINE'S TORSION PENDULUM for determining the moment of torsion of a wire and the moment of inertia of a ring.

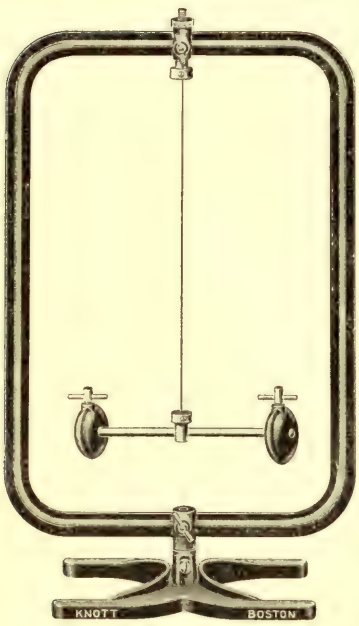
The design above illustrated obviates the annoyances of existing types. It is simple in design, self contained, and scientific in structure and appearance. Accurate results are possible with a minimum of trouble.

Two methods of reading torsional vibrations are possible, — by direct observation of consecutive transits of the index past the zero point of the graduated arc; by observing through a telescope the consecutive flashes from the illuminated mirror.

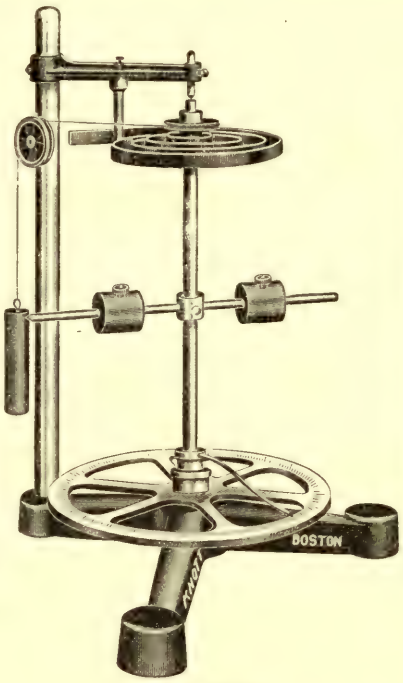
The disc is 10½ inches in diameter and is clamped to the wire by means of a small chuck fixed at its middle point. This disc is then supported from the frame by a similar chuck having the additional features of an adjusting thumb nut and a set screw. The index dial is cast from metal and has large raised figures. A ring whose moment of inertia is to be determined has the same diameter and mass as the disc.

Torsion pendulum, as illustrated but without mirror attachment **$14.60**

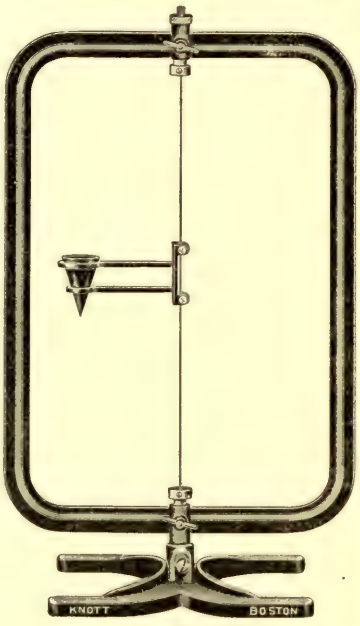
23–52 MIRROR ATTACHMENT complete, ready for attachment as illustrated above **1.25**



No. 23–60



No. 23–90



No. 23–100

23–60 TORSION PENDULUM for determining the moment of torsion for a steel wire and the moment of inertia of two iron weights.

The apparatus consists of a metal frame mounted to one of our substantial H bases. Suspended from the central part of this frame by means of a simple chuck is the suspension system consisting of a steel wire at the end of which is mounted a cross head carrying two disc-shaped metal weights fixed adjustably along the cross head.

Complete as illustrated **$4.25**

23–62 TORSION SYSTEM as used in above frame, all that is required if No. **23–50** or **23–100** is a part of the school equipment **1.85**

23–90 HARMONIC MOTION APPARATUS for verifying the Laws of Harmonic Motion (Ames and Bliss, page 111) by noting the rotational vibrations of a flat coiled spring.

This apparatus consists of a flat coiled spring mounted on a vertical axis supported in frictionless bearings, which, in turn, carries an arm with sliding weights to vary the inertia. The oscillations are indicated by a pointer over a graduated aluminum dial. The whole is mounted on a tripod base upright supporting the vertical axis and providing a support for a rod to which one end of the spiral is fixed. Handsomely finished throughout in bright japan, lacquered brass and nickel-plate.

Complete as illustrated **22.00**

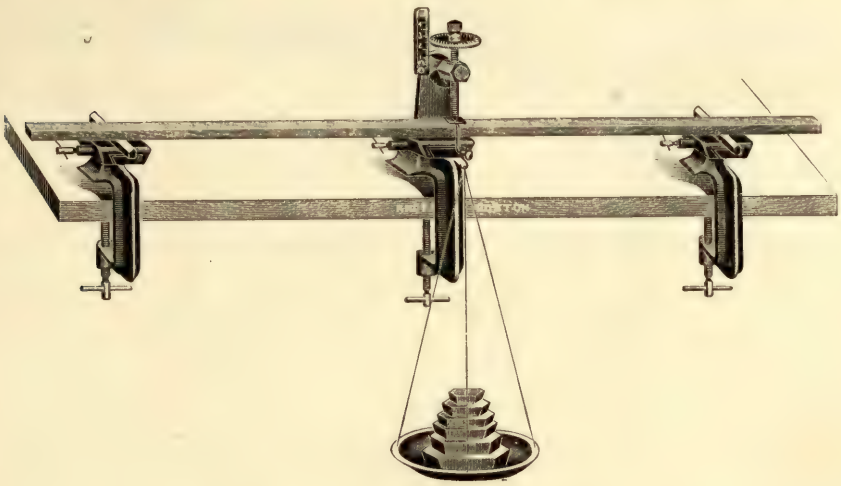
23–100 INERTIA BALANCE for determining the mass of a body without weighing.

The apparatus consists of a metal frame same as No. **23–60** mounted on our improved H base. To the center of the upper and lower sides are small chucks the upper of which may be adjusted in length by means of a thumb screw and firmly fixed by a T screw. This wire holds a small metal cone-shaped pan fixed to it by means of two screws. The apparatus is finished throughout in a manner to present a pleasing appearance and is carefully constructed to give the best possible results.

Complete apparatus as illustrated **4.25**

23–102 INERTIA SYSTEM as used in above frame, all that is required if No. **23–50** or **23–60** is a part of the school equipment **1.85**

FLEXURE OF BEAM APPARATUS



23–125 FLEXURE OF BEAM APPARATUS. This "set up" for determining by experiment the laws of elasticity of flexure is an arrangement of our Harcourt Universal T-Beam Clamps. (See Section **5**). Complete apparatus without basic clamps and weights **$7.00**

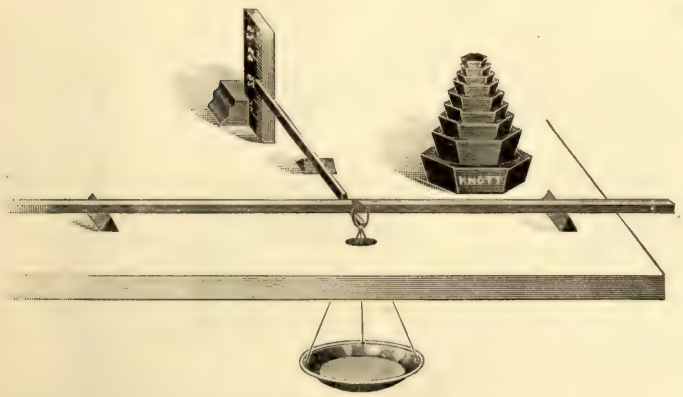
23–128 KNIFE EDGE CONTACT PIECE. This simple little device is for the purpose of attachment to the rod under experimentation so that the stress can be applied downward through a knife edge contact, and in addition furnishes means of securing good electrical connection with the micrometer screw. To this purpose the upper face of the contact piece is provided with a small plate having a projection for contact with the end of the micrometer screw. The lower part of the piece is provided with a hook for suspension of the scale pan, and has also a binding post for connection to battery **1.25**

23–130 SCALE PAN . . . . . **.12**

WEIGHTS. Section **16.**

Other apparatus illustrated above and listed elsewhere is as follows:

5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP
"A" (Three required) . . . . . Each **$1.15**



23–140 FLEXURE OF BEAMS APPARATUS for determining by experiment the laws for elasticity of flexure.

The apparatus consists of three triangular prisms two of which are designed to support the rod under test, the third to act as the fulcrum of the lever indicator. A vertically mounted rule gives the measure of the movement of the long arm of this lever. The scale pan attached directly over the short arm of the lever and over the rod serves as a support for the weights which cause the stress.

Complete apparatus as illustrated, without weights, including the three prisms, two pine rods of different cross sectional area, one lever indicator with supported scale and scale pan **$0.70**

23–141 SUPPORTING TRIANGULAR PRISMS . . . . . Per Set of Three **.24**

23–142 PINE ROD, 100 centimeters × ½ × 1 inch . . . . . **.12**

23–143 PINE ROD, 100 centimeters × ½ × ½ inch . . . . . **.10**

23–144 LEVER INDICATOR . . . . . **.08**

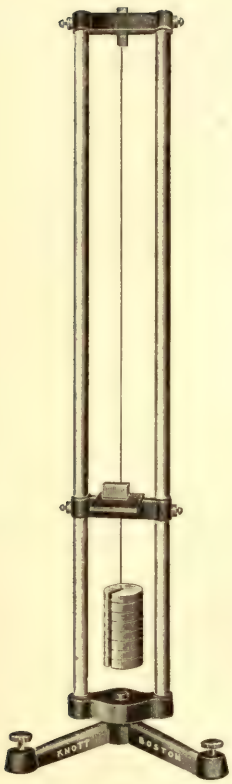
11–70 MOUNTED 10-centimeter Scale . . . . . **.16**

23–130 SCALE PAN . . . . . **.12**

WEIGHTS. Section **16.**

23–156 PAIR OF WOODEN SUPPORT BLOCKS, after Millikan & Gale's "A Laboratory Course in Physics," Experiment 12 . . . . . **.55**

23–157 STEEL ROD, after Millikan & Gale's "A Laboratory Course in Physics," Experiment 12 . . . . . **.10**



No. 23–180

23–180 HOOKE'S LAW and **YOUNG'S MODULUS APPARATUS,** for testing Hooke's Law and determining Young's Modulus for a wire.

This apparatus consists of two parallel rods supported on a tripod with leveling screws. In the upper casting clamping the rods is a small metal chuck for clamping the upper end of the wire to be tested. In a hole in the center of the movable casting is a second chuck which is set into a cylindrical brass piece which moves with very little play in this hole. This movable casting bears an accurately adjusted optical lever the front feet of which rest on a small table incorporated in the casting. The rear foot rests upon the carefully ground top surface of the brass piece bearing the chuck. Three two-kilogram and two one-kilogram weights which are supplied with the apparatus may be placed on the weight hanger to give the stretching force.

This apparatus is solidly built and its structure is of most painstaking type. Accurate results are easily obtained.

Complete as described **$25.00**

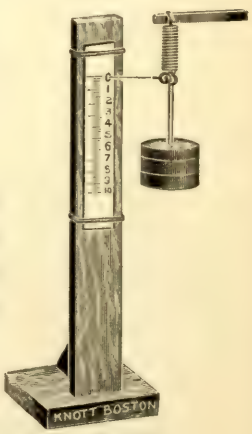
23–190 HOOKE'S LAW APPARATUS as required in Millikan & Gale's "A Laboratory Course in Physics," Experiment 12.

Complete apparatus as listed below **$3.45**

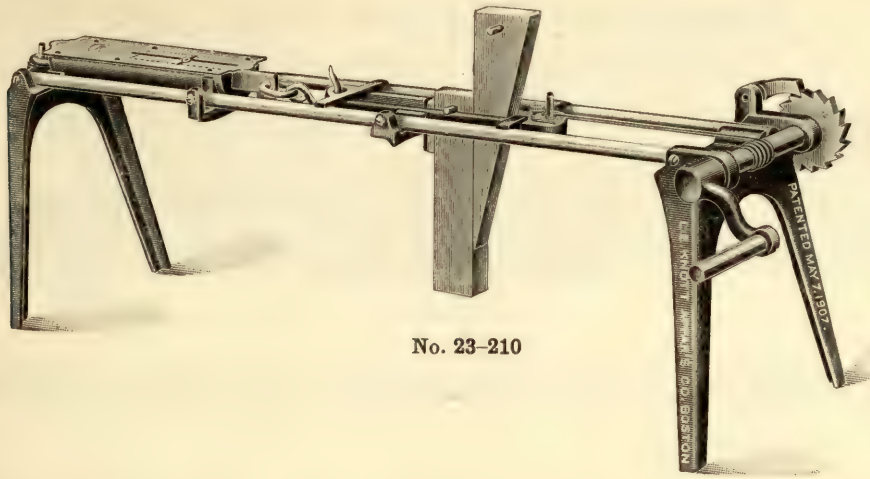
23–191 MIRROR SCALE and **UPRIGHT WOODEN SUPPORT** **1.40**

23–192 SPRING and **WEIGHT HOLDER** . . . . . **.40**

16–460 WEIGHTS and **HOLDER** **1.70**



No. 23–190



No. 23–210

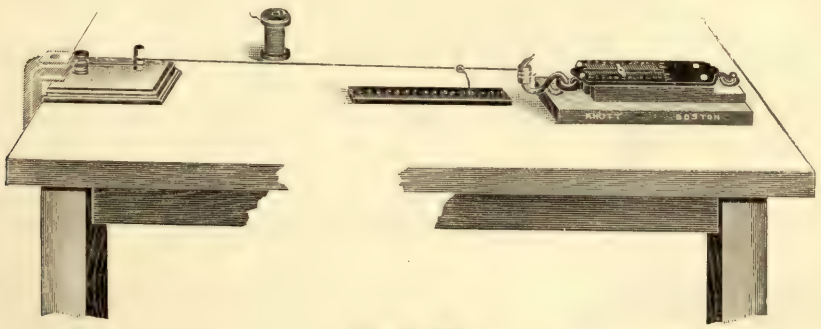
23–210 BREAKING STRENGTH OF WIRES APPARATUS, for measuring the tensile strength of wires.

This apparatus must not be confused with the various forms on the market. It is designed to do all and more than the others will do, and to facilitate in rapid and accurate determinations. It is constructed entirely of metal. The essential features consist of cast metal legs, to which are rigidly fastened two nickel-plated steel rods to form the bed of the instrument. To the bed are clamped the cradle for the dynamometer and a recoil frame. The ring of the dynamometer slips over a peg on one of the end castings. The hook is attached to the recoil frame. The design of this recoil frame is simple and most effective. It is a metal casting provided with binding device for one end of the wire whose textile strength is to be tested and the retaining frame with buffer for recoil wedges. Our tension device consists of a crank operating an axle about which the wire winds as the tension increases. Danger of recoil of crank is entirely obviated by means of a ratchet and pawl attached to one end of the axle.

Results of experience have demonstrated that in this design we offer an instrument obviating objectionable features of less carefully and scientifically designed instruments. Our instrument will form a valuable acquisition for any well appointed laboratory.

Complete with double scale dynamometer, 30 pounds and 15 kilos $6.60

23–211 ——, same as above, but without dynamometer 5.00



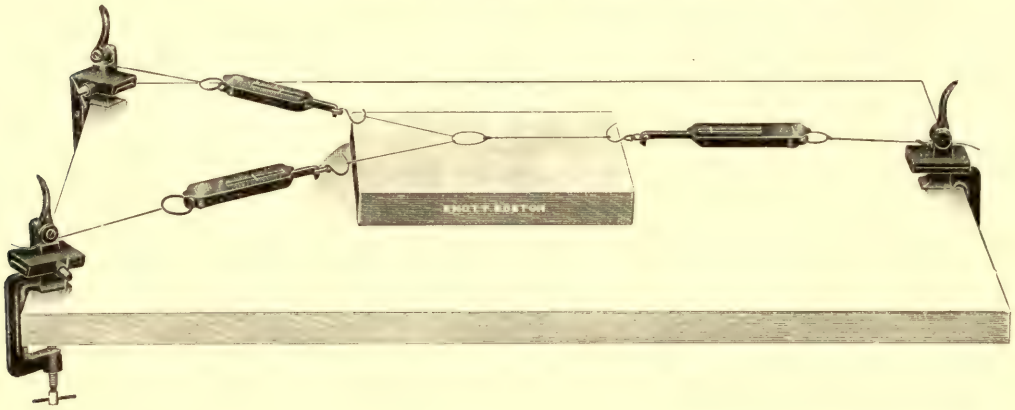
No. 23–225

23–225 ELASTICITY OF WIRE APPARATUS, for determining the Coefficient of Elasticity of Wire.
Complete apparatus as above illustrated but without Spring Balance and Basic Clamp $2.15

SEPARATE PARTS.

23–226 SPOOL SPRING BRASS WIRE, No. 27 40
23–227 T. & H. STRETCHING BLOCK WITH WOOD PILLAR AND BRASS BINDING POST 90
23–228 MARKER CLAMP AND STYLUS 20
5–1150 T-BEAM BASIC CLAMP "B" 1.90
15–315 SPRING BALANCE, 15 kilos and 30 pounds 1.65
23–231 MOUNTED MILLIMETER SCALE 20
15–365 SPRING BALANCE SUPPORTING CRADLE 45

COMPOSITION OF FORCES

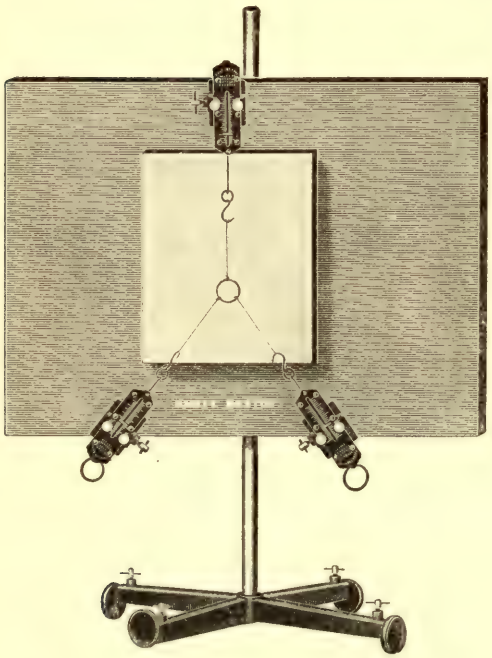


For the "set up" of the experiment above illustrated no new apparatus is required. Articles shown above are as follows:

5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "A." (Three needed) . . . . . Each **$1.15**

5–1065 STONE'S TENSION CLAMP ATTACHMENT. (Three needed) . Each **.48**

15–310 SPRING BALANCE, 2000 grams and 64 ounces. (Three needed) . Each **.45**



The only distinctive item shown in accompanying illustration is the following:

24–15 STRAIGHT-GRAINED SUPPORT BOARD with side ledges and provided with clamp at back for attaching to any 19-millimeter rod **$2.20**

Other apparatus illustrated has all been previously listed as follows:

5–1000 HARCOURT T-BEAM BASIC CLAMP "A." (Three required) . . . . . Each **1.15**

5–1070 BALANCE CRADLE ATTACHMENT. (Three required) . . . . . Each **.66**

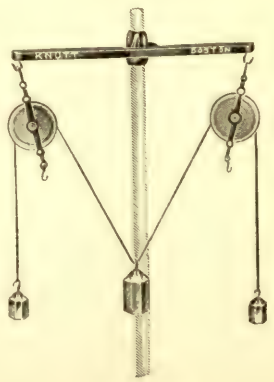
5–250 KNOTT ADJUSTABLE ECCENTRIC LEVELING BASE **2.35**

5–20e SUPPORT ROD, 19-millimeter diameter, 100 centimeters long **1.00**

NOTE. — Universal Stand No. **22–130** may be used in place of the last two items if so desired.

24–25 COMPOSITION OF FORCE ATTACHMENT for use on any 19-millimeter rod in the study of equilibrium and composition of forces. This attachment consists of a metal casting with clamp and cross-head in one piece. The cross-head is provided with hooks for hanging pulleys.

Attachment only, without pulley or weights illustrated **$1.15**



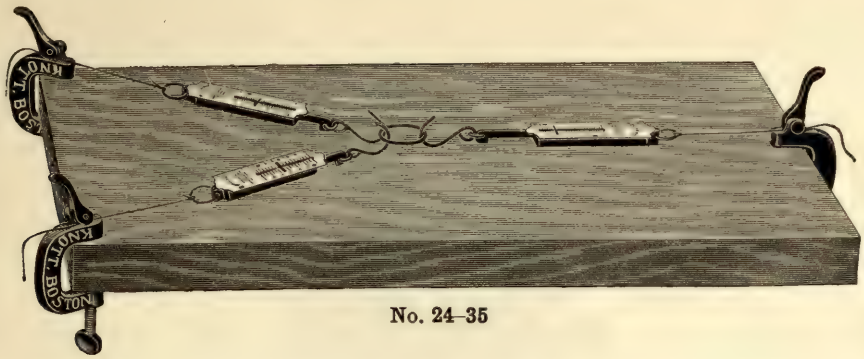
No. 24–25

ACCESSORY APPARATUS ELSEWHERE LISTED:

22–130 UNIVERSAL STAND **$2.00**

27–150 BALL-BEARING SINGLE PULLEY. (Two required) . . . . . Each **.55**

16–450 UNIVERSAL WEIGHTS. Set with holder . **2.50**

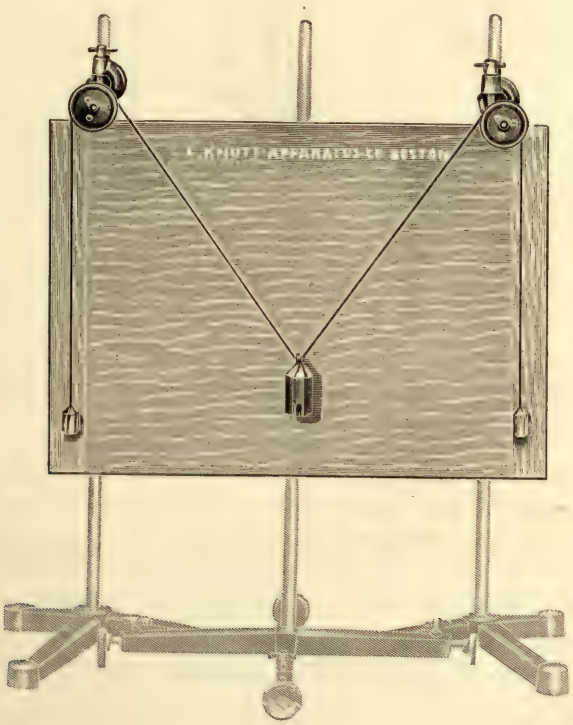


No. 24–35

24–35 STONE'S TENSION CLAMPS for holding either a string or wire firmly yet adjustably; convenient for use with Spring Balances as illustrated in determining the Parallelogram of Forces.

This clamp consists of a casting with jaws wide enough to fit over the ordinary Physics Laboratory Table. A nickel-plated T-screw is provided for firmly fixing to the table. The wire is threaded under a small cam lever which binds or releases by only a slight motion of the lever. Per set of three **$1.35**

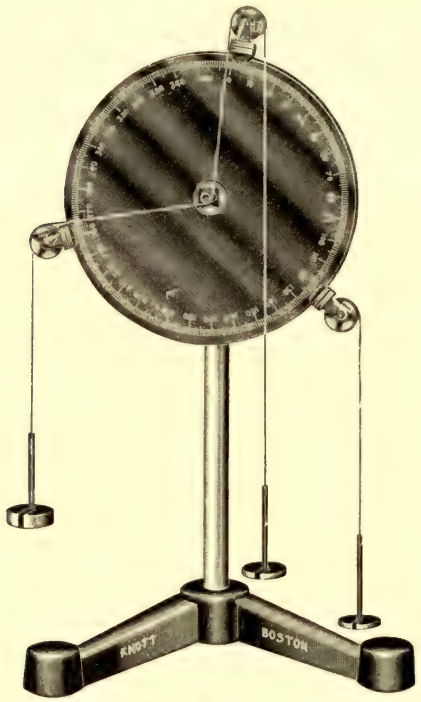
24–36 STONE'S TENSION CLAMP . . . . . Each **.45**



COMPOSITION OF FORCES

Items above illustrated assembled will all be found previously listed, and if already a part of the school equipment will not be needed. They are as follows:

5–250	**KNOTT ADJUSTABLE ECCENTRIC LEVELING BASE**		**$2.35**
5–20e	**SUPPORT ROD,** 19 millimeter diameter, 100 centimeters long		**1.00**
22–130	**UNIVERSAL STANDS.** (Two required)	Each	**2.00**
5–770	**RIGHT-ANGLE CLAMPS.** (Two required)	Each	**.95**
5–952	**PULLEY ON ROD.** (Two required)	Each	**.90**
16–450	**UNIVERSAL WEIGHTS.** Per Set with Holder		**2.50**
24–15	**SUPPORT BOARD**		**2.20**



No. 24–60

24–60 PARALLELOGRAM OF FORCE TABLE for use in either **HORIZONTAL** or **VERTICAL POSITION** in deriving Laws of Parallelogram of Forces.

This instrument is intended for high-grade work in the quantitative determinations of the Laws of Parallelogram of Forces. Built throughout of metal, it is extremely substantial, and being beautifully nickeled and japanned, presents a handsome appearance. The apparatus consists of a smooth nickeled iron disc 35 centimeters in diameter, divided into degrees. It is mounted in such a manner that it can be used in either a vertical or horizontal position. Frictionless bearing brass pulleys are provided for attachment to the edge of the disc. By the use of a special centering arrangement, weights and weight holders, very accurate results are possible with this table.

Complete as illustrated, with three frictionless bearing brass pulleys, centering arrangement, weights and weight hangers, mounted on a 60-centimeter rod on tripod base **$22.00**

24–61 PARALLELOGRAM OF FORCE TABLE, same as No. **24–60,** but mounted on a 100-centimeter rod and with tripod with three leveling screws **27.00**

24–62 PULLEY WITH BRACKET, as used in Nos. **24–60** and **24–61** . . . . . Each **2.50**

WEIGHTS AND WEIGHT HOLDERS. Section **16.**

No. 24–80

24–80 COMPOSITION OF FORCE BOARD as used in Millikan & Gale's "A Laboratory Course in Elementary Physics."

This is a well-seasoned board, 30 × 19½ inches, to the back of which are fastened two strips of wood, which serve the double purpose of preventing warping and as a support. They are of sufficient length so that the board may rest vertically. Holes into which pegs may be placed are conveniently located on each quarter surface of the board, thus providing a convenient setting for a pin to which strings from a Spring Balance may be attached.

The Board, with three pegs, but without Balances **$1.75**

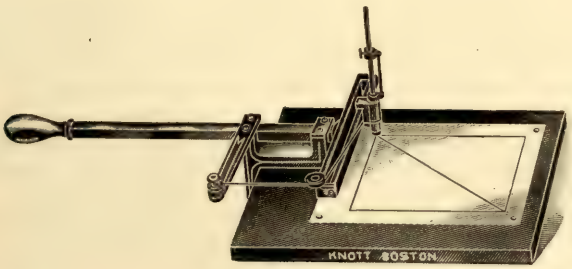
24–85 COMPOSITION OF FORCE BOARD after Prof. E. H. Hall for use with Spring Balances in formulating the laws of Composition of Forces.

This apparatus consists of a board 15 inches square with forty-nine holes equally spaced in squares. Pins are provided which may be placed in any hole desired, to which may be attached the strings from the hooks of Spring Balances. That the board may move freely, four spheres are provided, which, when placed next to the retaining rims on the under side, will act as ball bearings. This board has a sandpaper and oil finish and is substantially built throughout.

Board with four pegs and four balls **2.00**

24–90 GILLEY'S COMPOSITION OF FORCE BOARD, similar to above but smaller in size. Constructed of close-grained hardwood, 9 × 9 inches **1.00**

ACCURATELY TURNED STEEL BALLS. Section **22.**



No. 24–100

24–100 GAGE'S COMPOSITION OF FORCE AND MOTION APPARATUS for the graphic representation of the components and resultant of two forces.

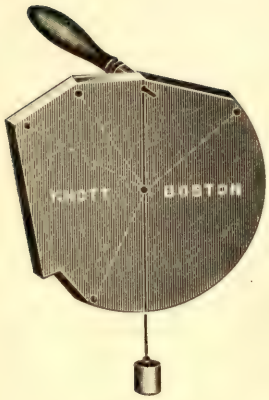
The apparatus consists of a flat board to which is clamped an attachment consisting of a clamp holding in a sliding fit a square rod, with cross head which in turn carries a slide with pencil clamp. This pencil clamp is free to move along a rod parallel to the cross head and is connected by a string around a pulley to the end of the arm attached to the clamp holding the apparatus to the board.

Results possible with this apparatus arouse the interest of pupils in the Resolution of Forces. It is pedagogically superior to much that is on the market for the graphic representation of forces.

Complete as illustrated **$9.75**

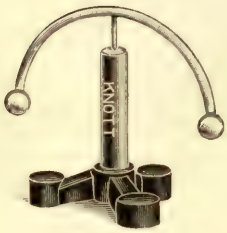
FORCE OF GRAVITATION

EQUILIBRIUM — Stable, Unstable and Neutral

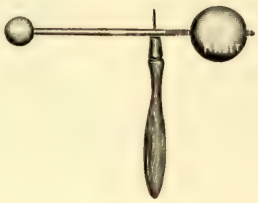


No. 25–10

No. 25–55



No. 25–15



No. 25–20

No. 25–50

25–10 CENTER OF GRAVITY BOARD for determining the center of gravity of an irregularly-shaped board.
This apparatus consists of a board of irregular shape drilled at various points. If the board is held suspended from these several points, and a plumb line dropped from each, it will be found that these lines all intersect at one point, — the center of gravity.
Board complete with handle support and plumb bob **$0.95**

25–15 MOUNTED CENTER OF GRAVITY ARC for illustrating stable and unstable equilibrium. This apparatus consists of a brass arc on which are threaded two brass balls which may be adjusted along the arc, thus changing the position of the center of gravity. To the center of this arc is attached a post with pivoted end. In use this pivoted end is placed in the concave top of the pillar of the supporting stand.
With balls in position as illustrated the movable system is in state of stable equilibrium, but if the balls are raised above the level of the pivot the equilibrium becomes unstable.
Complete as illustrated with supporting stand **1.10**

25–20 CENTER OF GRAVITY SYSTEM for illustrating the center of gravity.
The apparatus consists of two brass spheres of different sizes connected by a rod in which are drilled two holes, one at the geometric center, the other at the center of gravity. A support handle is supplied with each instrument.
Complete as illustrated . . . . . **.90**

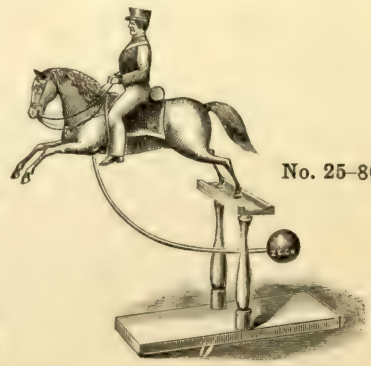
25–50 LOADED CYLINDER WHEEL for illustrating the center of gravity of a loaded wheel.
This apparatus consists of a wooden disc loaded near the edge and drilled at the geometric center and at the center of gravity. A suitable upright for support is also furnished **1.05**

25–55 LOADED CYLINDER, illustrating the tendency of a body to place its center of gravity as low as possible.
This is a wooden cylinder loaded eccentrically, and if rolled along a horizontal surface will strive to rest on its loaded side . . . . . **.30**

25–60 WITCH, illustrating the tendency of a body to keep its center of gravity as low as possible.
This apparatus consists of a hemispherical piece of metal to which is attached a short length of pith . **.12**

No. 25–75

25–75 LEANING TOWER, illustrating stability when a line drawn through the center of gravity comes within base of support.
This inexpensive device illustrative of the celebrated Leaning Tower of Pisa is built of wood with a removable top and foot. With the foot in place, the tower will stand so that its center of gravity is in center of circle of the base. With foot removed and top in place, the center of gravity being without the base, the tower will topple over. With top taken off, the tower will stand stable, the center of gravity coming within the base **$1.20**

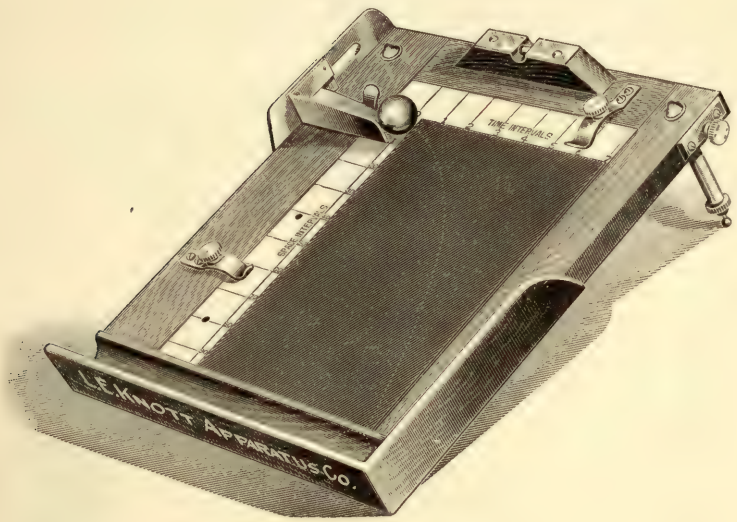


No. 25–80

25–80 HORSE AND RIDER, illustrating equilibrium when line drawn through the center of gravity comes within base of support.
The apparatus consists of wooden figures representing a horse and rider. A wooden ball is attached to the figures so that its weight changes the center of gravity to come within the base of support. A striking illustration of the principle is possible as pictured . . . . . **.95**

FALLING BODIES

ACCELERATED MOTION



No. 25–100
Patented December 17, 1907

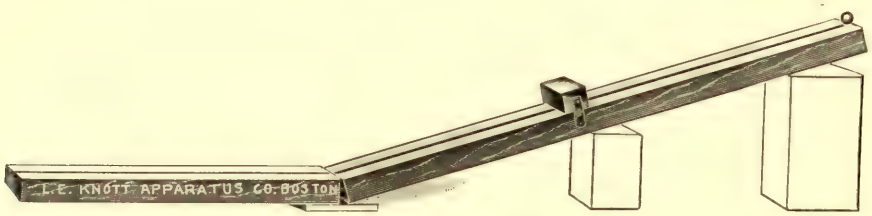
25–100 PACKARD'S FALLING BODY APPARATUS for the determination of the Laws of Accelerated Motion with their application to falling bodies, the data being obtained from the path that the falling body traces during descent.

This ingenious invention of Mr. John C. Packard of the Brookline High School, Brookline, Mass., is, in its fundamental principle, a greatly improved inclined plane. It consists of a board of a design to meet the special requirements. A quick-acting spirit level is attached for obtaining the necessary plumb in one plane. Adjustable legs at one end afford facilities for varying the angle of tilt for changing the conditions. In use, a steel ball is allowed to roll down over the smooth surface of a sheet of paper covered with a soft carbon tracing paper. There will be found on the board, effective devices for clamping the paper and for holding and releasing the ball as required. Results obtained by even the most careless students are ample recommendations for the purchase of this instrument.

Complete with 12 sheets Cross-section Paper and 2 sheets Carbon Paper. Special circular on request **$6.25**

25–101 CROSS-SECTION PAPER, special ruled . . . . . Per Ten Sheets **.30**

25–102 CARBON PAPER, especially adapted for use with No. **25–100** . . . . . Per Sheet **.07**



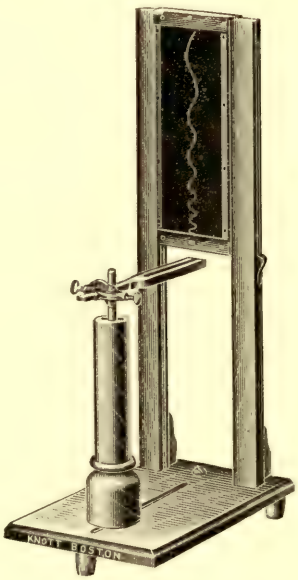
Nos. 25–110 to 25–112

25–110 **FALLING BODY APPARATUS,** retardation to free fall secured by **INCLINED PLANE** according to Millikan & Gale's "A First Course in Physics," page 26, for determining the distance traversed by a body under force of gravity in one, two, three, or four seconds under uniformly accelerated motion.

The apparatus consists of a clear, straight-grained wooden plank, 16 feet long, with accurately cut V groove running the total length, which, when inclined at an angle, affords an inclined plane down which a steel ball may be rolled in a frictionless path. A block stop for this ball is furnished which may be clamped to the plane at any position desired. Time interval may be noted by any convenient means. We recommend either a Seconds Pendulum No. **17–50,** or a Metronome No. **17–120** **$5.50**

25–112 **FALLING BODY APPARATUS,** same as above, but 8 feet long. This is to be used in connection with above for measuring velocity acquired per second by a body under force of gravity in uniformly accelerated motion **2.50**

No. 25–120



No. 25–140

25–120 **FREE FALL DEMONSTRATION APPARATUS** or **GUINEA AND FEATHER TUBE** for demonstrating that all bodies, even if of different masses, fall in equal intervals of time if released from friction of air pressure.

This apparatus consists of a large glass tube, one end sealed air tight, the other end with a brass cup with stop-cock, bodies of different masses being enclosed previous to sealing **$6.75**

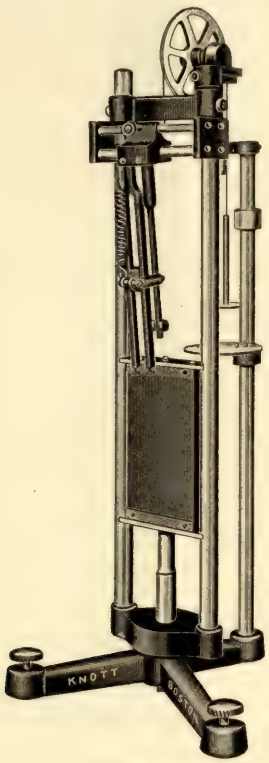
25–140 **FALLING BODY APPARATUS** (Ames and Bliss' "A Manual of Experiments in Physics," Experiment 21) for determining the linear velocity and acceleration of a rapidly-moving body.

The apparatus consists of a weighted glass plate free to slide in a vertical frame. An adjustable upright support with clamp for holding a heavy tuning fork of low pitch is mounted on the same base.

In use, the plate is covered with an even layer of smoke soot, " Bon Ami," or whatever is desired to give it a tracing surface. A fork with attached stylus is fastened in the clamp and adjusted so that the stylus will mark the plate as it is allowed to drop from the top of the upright frame

Price, without fork **5.85**

51–65 **TUNING FORK,** adapted for use with above. 128 V. P. S. **3.00**



No. 25–160

25–160 ACCELERATION APPARATUS, for determining the acceleration of a freely-falling body moving with uniformly accelerated motion.

The falling body is a metal frame to which a heavy glass plate is held by spring clamps. This metal frame with its glass plate falls before an electrically driven tuning fork, of known vibration number and which may be moved sideways to enable one plate to take several readings. In making an observation the plate is drawn to the top of the frame and fastened by a thread. The stylus is now adjusted to touch the plate. The tuning fork is set in vibration, the string is burned in two and the descending plate receives a fine tracing on its blackened or whitened surface. Measurements are taken directly from the plate by means of a divider or scale. Frequently the tracing is projected on a screen by means of a lantern.

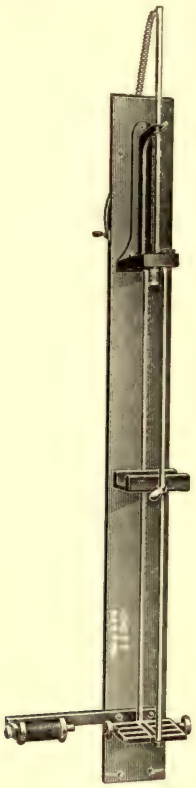
The apparatus may be used as an Atwood's Machine by attaching a light aluminum wheel on ball-bearing to the frame. This wheel carries a cord holding the falling plate on one end and the counterbalancing weights on the other. The platform and ring may be easily attached to the frame.

Complete with Atwood's Attachment **$45.00**

25–161 ACCELERATION APPARATUS, same as above, but without Atwood's Attachment **25.00**

25–162 ——, same as above, but with double the range **35.00**

NOTE. — The glass plate of Acceleration Apparatus **Nos. 25–160** to **25–162** is generally coated with lamp-black over a gas-jet or burning camphor. A much more cleanly method will be found in making a thin paste of alcohol and whiting, which may be rapidly applied to the plate with long strokes of a camel's-hair brush or a soft sponge.

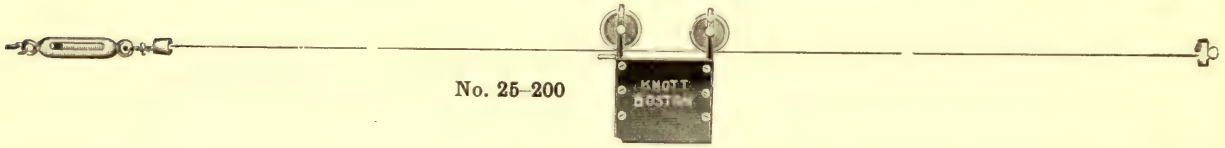


No. 25–180

25–180 FREE FALL APPARATUS (Stewart and Gee's "Elements of Practical Physics," page 239), for finding the time taken by a body falling freely from a height, and in determining the value of "g."

The factors in determining the value of "g" are determined by the free fall of a steel sphere from the bronze-tipped electro-magnet at the end of a vertically adjustable brass rod to a slit at the lower end of a pendulum whose period may be varied. The position and width of the slit is adjusted so that the sphere dropping vertically passes through it when the pendulum is at its lowest point. The electro-magnet holding the sphere and the one drawing the pendulum aside are in the same circuit, which, when opened, releases both simultaneously. If the time of fall equals the quarter period of the pendulum, the sphere passes through the slit. By raising or lowering the brass rod, this equality may be easily produced. One jaw is covered with lead, in order that the experimenter may determine by ear whether the sphere arrives at the plane of the slit too soon or too late. The period of the pendulum gives the time of the fall. The distance is measured from the bottom of the suspended sphere to the plane of the slit.

We unhesitatingly recommend this apparatus for very accurate determinations of "g" **$25.00**



No. 25–200

25–200 UNIFORMLY ACCELERATED MOTION APPARATUS for study of principles of accelerated motion and for determination of factors governing a body under uniformly accelerated motion.

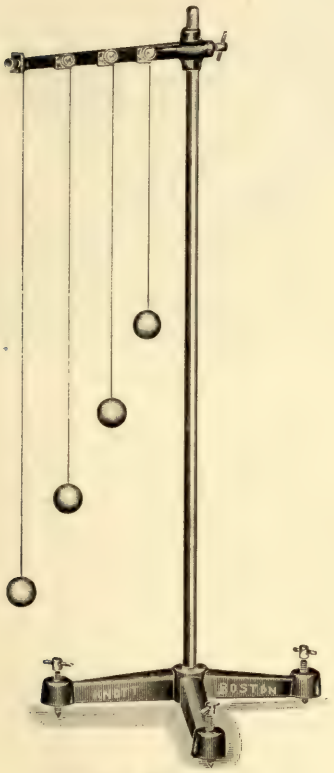
The apparatus consists of a car which, mounted on a wire inclined at a slight angle, is free to move down the incline. The wire is provided with a hook at one end and a turn-buckle at the other for securing taut wire.

Apparatus complete as illustrated **$3.40**

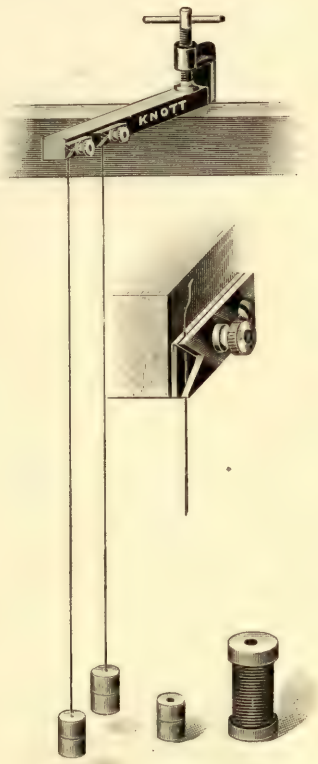
25–201 LYON'S CAR, with buffer **1.80**

25–202 INCLINED-WIRE OUTFIT, including screw, hooks, and turn-buckle with buffer **1.60**

PENDULUMS



No. 25–225



No. 25–230

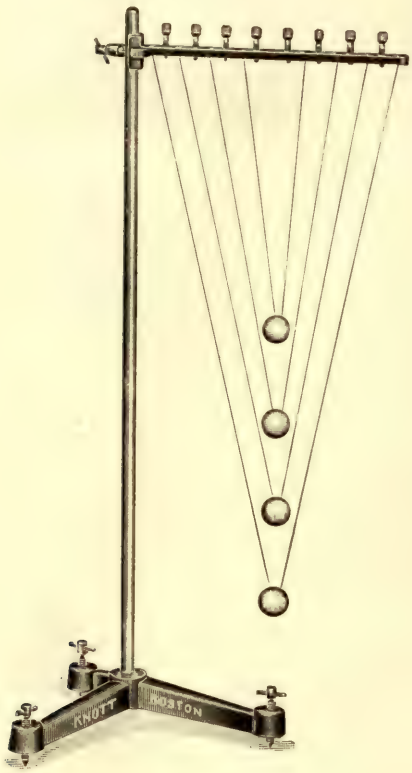
25–225 **PENDULUM ILLUSTRATION** for determining factors governing the laws of pendulums.
The apparatus illustrated must not be confused with similar designs on the market, as it will be noted that our instrument will support in adjustable suspensions four pendulums.
Pendulum Clamp with four balls but without support **$1.95**
5–900 **PENDULUM CLAMP** only **1.45**
Support illustrated is **22–131 UNIVERSAL STAND** **3.00**

25–227 **PENDULUM ILLUSTRATION,** same as above, but with our No. **5–902** Pendulum Clamp for holding three pendulums in adjustable suspensions.
Pendulum Clamp with three balls but without support **1.45**
5–902 **PENDULUM CLAMP** only **1.05**

25–230 **PENDULUM APPARATUS** after Turner and Hersey, for the determination of the Laws of the Pendulum.
The apparatus consists of a special pendulum clamp, details of which are shown in illustration, each designed to hold two pendulums. For different masses, we list three bobs of different metal; for suspensions, fine wire.
In use, the pendulum clamp is attached by means of an iron clamp (our No. **5–1150** Harcourt Basic Clamp "B" being shown in the illustration) to a convenient support, the Cross Beam of our Standard Physics Table No. **1–100**, being illustrated.
Apparatus complete without Basic Clamp **2.15**

SEPARATE PARTS

25–230a **PENDULUM CLAMP** as used in above **$0.95**
25–230b **SPECIAL CYLINDRICAL IRON BOB** . . . . . **.25**
25–230c **SPECIAL CYLINDRICAL LEAD BOB** . . . . . **.30**
25–230d **SPECIAL CYLINDRICAL BRASS BOB** . . . . . **.30**
25–230e **SPOOL COPPER WIRE,** No. **30** . . . . . **.35**
5–1150 **HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "B"** **1.90**



No. 25–235

No. 25–260

25–235 PENDULUM ILLUSTRATION for determining factors governing the Laws of Pendulums.

This apparatus consists of our No. **5–905** Pendulum Clamp with four balls of equal diameter. These balls are attached to the clamp by threads of lengths to obtain vibration periods as **1**: **2**: **3**: **4**.

Pendulum Clamp with four balls, but without illustrated support **$3.45**

5–905 PENDULUM CLAMP only **2.90**

Support illustrated is

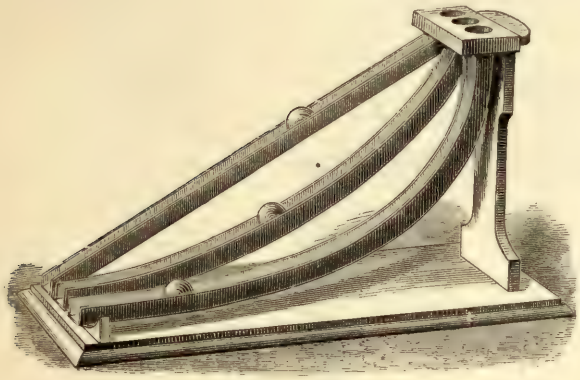
22–131 UNIVERSAL STAND **$3.00**

25–260 REVERSIBLE PENDULUM for determination of centers of suspension and oscillation, and, by measurement of the distance between these centers, to determine the length of the equivalent simple pendulum and, from this, the value of the acceleration of gravity.

This design consists of a nickel-plated metal rod on which are two lens-shaped bobs each provided with steel knife-edges with the edges of one turned towards the edges of the other. These bobs may be adjusted along the rod as desired, thus changing the centers of suspension or oscillation at will. The pendulum is suspended on the knife-edges of one of the discs on the bracket and stirrup, as above illustrated. The bobs are now fixed at such a distance apart that the pendulum vibrates with the same period, whether it is suspended from knife-edges of one bob or the other,—the center of suspension becoming the center of oscillation when the pendulum is reversed. The distance then between the knife-edges is the length of an equivalent simple pendulum.

Reversible Pendulum complete with stirrup and bracket **3.95**

GRAVITY AND MOTION



No. 25–310

No. 25–320

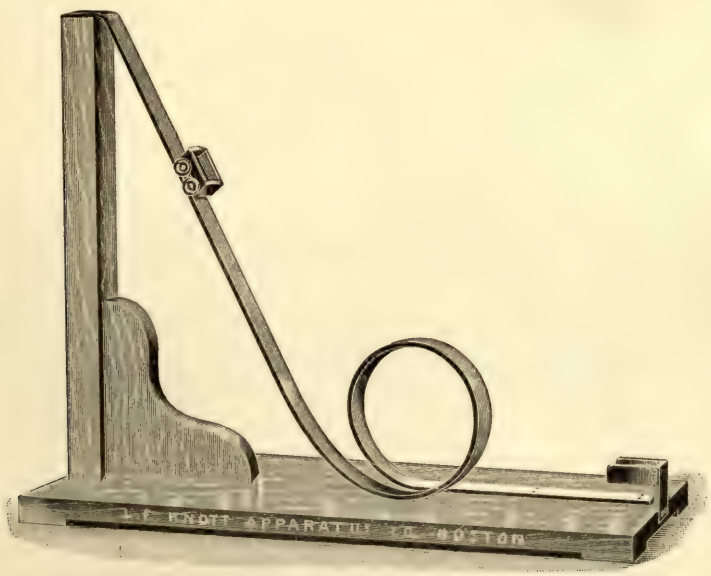
25–310 **SWIFTEST DESCENT APPARATUS,** comparing descents of spheres of the same diameter along inclines of different curvatures.

The apparatus consists of three tracks placed on an incline to the base line, — one track describing a cycloid curve, the second a concave circular curve, the third an inclined plane. The apparatus is further provided with a device for the simultaneous start of all three spheres. The singular results follow a simultaneous start of all three spheres, — the sphere on cycloidal curve reaches end of track first, on concave circular track second, while the one on the inclined track is the slowest. One other striking experiment will be noted, — no matter from which point on the cycloidal tract the sphere is started, the time of descent to the end of the track will always be the same.

Complete with three steel spheres **$21.25**

25–320 **DOUBLE CONE AND PLANE,** for illustrating the seemingly paradoxical phenomenon of a cone moving up an incline, which is of such shape that its axis actually descends.

Complete as illustrated, of finely grained and neatly polished wood **1.15**



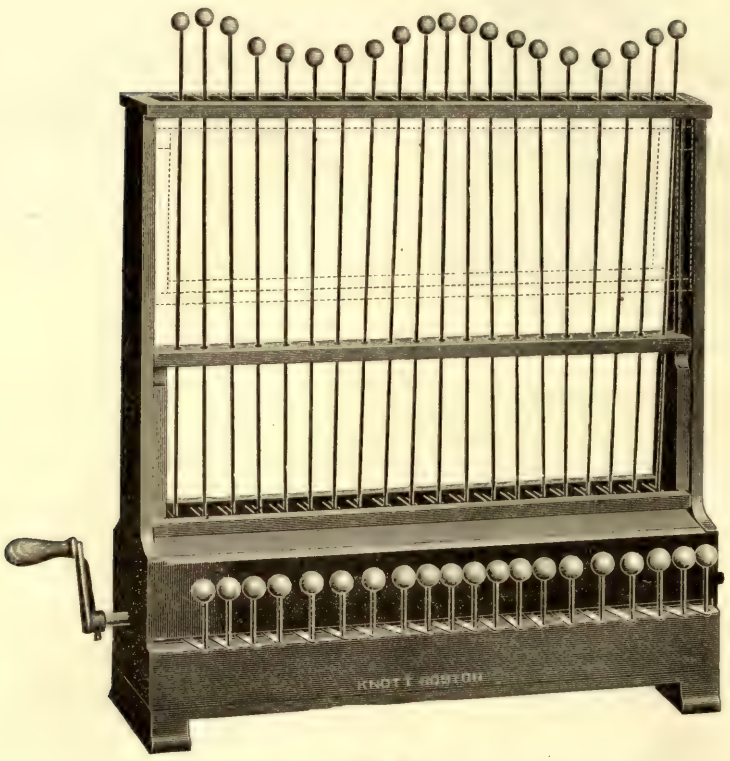
No. 25–330

25–330 **CENTRIFUGAL RAILWAY,** illustrating the opposition offered by a moving body to any influence exerted to counteract its tendency to move in a straight line.

This apparatus consists of a looped circular railway down which a body may roll unobstructed. At one point in the loop illustrated, the body is held by centrifugal force against the under side of the track in opposition to the force of gravity.

Complete as illustrated with car . . . . . Duty Free **$17.50**

WAVE MOTION



No. 26–10

26–10 UNIVERSAL WAVE MOTION APPARATUS, modification of Powell's and Snell's designs, combining features of both into one instrument capable of demonstrating all principles of each. Thus the combination transverse and longitudinal component illustrating waves on surface of a liquid, wave motion as set up by transverse displacements, and wave motion as set up by longitudinal displacements are all strikingly shown.

WATER WAVES. In our model we show that the particle or element on the crest moves forward, in the trough backward, and in the intermediate positions both vertically and horizontally. The elliptical or circular orbits of the disturbed particles are ample in size that they may be readily observed by all even in the largest lecture hall. It may also be shown that the wave form is not a sine curve.

TRANSVERSE WAVE FORM. The demonstration of movement of a particle transversely and the transverse wave form as well as the analysis of the resultant sine curve is especially adapted to this model.

LONGITUDINAL WAVE FORM. Our model is so designed that in demonstrating any of the above forms the condensations and rarefactions set up by longitudinal vibrations will also be formed, thus affording a striking comparison of wave forms.

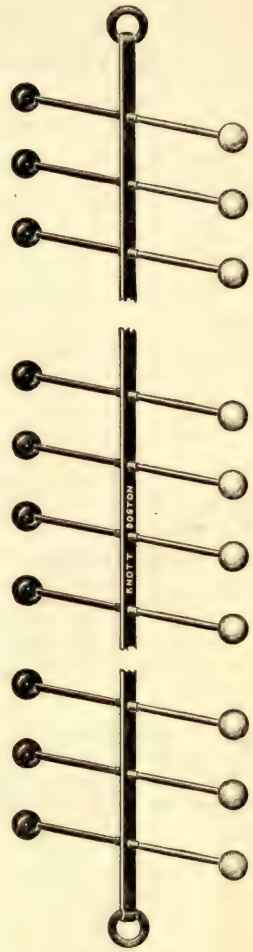
This model stands about three feet high and all parts are so proportioned that it is especially adapted for lecture purposes. The elements are represented by balls; vibrations, transverse or longitudinal, are communicated by brass rods; and the vibrations are set up in the rods by means of peculiarly cam-shaped castings eccentrically mounted, each rod to its own casting, and all on a shaft operated by a single crank. When the rectangular guide frame " A " is in the position illustrated both transverse and longitudinal wave motions are demonstrated. With " A " in position as indicated by dotted lines water waves and longitudinal waves are demonstrated.

This apparatus is carefully assembled and all parts accurately made. All woodwork is neatly finished and the whole presents a scientific and handsome appearance **$65.00**

26–20 WAVE APPARATUS for illustrating the formation of transverse and longitudinal waves.

This model consists of a steel ribbon along which, at regular intervals are securely fixed cross heads bearing at either end a metal ball, rod and balls on either side of the ribbon being painted a distinguishable color that various wave forms may be easily differentiated. This steel ribbon in use is firmly fixed to the ceiling by means of the heavy screw-eye furnished with the apparatus. By giving the lowest cross bar a motion at right angles to the steel ribbon a motion is communicated to each cross bar in turn, illustrating transmission or propagation of transverse waves. Longitudinal waves are propagated in similar manner by depressing one end of the lowest cross bar in a vertical direction, the motion thus being communicated throughout the entire length.

The use of this wave model fully warrants the expense, as results obtained are entirely satisfactory and may be seen from the rear of the largest lecture hall. The model is about 13 feet long, with cross bar attached every five inches **$10.40**



No. 26–20

No. 26–30

26–30 SPIRAL SPRING for illustrating wave motion, either transverse or longitudinal.
This spring is constructed of spring brass wire coiled in the form of a spiral. Length about 3½ meters. (Same as illustrated in Section **55**). . . . **1.95**

26–31 SILK CORD for illustrating wave motion. As silk is strong and pliable, this cord affords an excellent demonstration of wave propagation. Length about 3½ meters. (Same as in Section **55**) **1.15**

26–32 RUBBER CORD for illustrating wave motion. Length about 3½ meters. (Same as in Section **55**) . . . . . **.85**

No. 26–40

26–40 WAVE TROUGH for illustration of water waves. This trough is a rectangular hard wood case, open at the top, with plate glass sides. Its size, 10 inches high, 2½ inches wide, and 5 feet long, is ample for class room demonstration. The plate glass sides are carefully sealed in, to prevent any leakage whatsoever; the woodwork carefully finished moisture proof. Lengthwise of one of the plate glass sides is drawn a black line, 10 centimeters above the floor of the trough and parallel with it. In use the trough is filled to this line and waves are set in motion by means of the paddle illustrated. This instrument makes a valuable demonstration instrument and is durably and handsomely finished.

Complete as illustrated, with paddle **$12.50**

SIMPLE MACHINES

LEVERS, PULLEYS, WHEEL AND AXLE, INCLINED PLANE, WEDGE, SCREW

No. 27–30

27–10 COEFFICIENT OF FRICTION APPARATUS for the study and determination of the Coefficient of Friction.

The apparatus consists of a white wood strip, 50 × 20 centimeters, with its surface carefully planed smooth. The friction between this surface and the face of a wood block, 7.5 centimeters square, is determined by means of a Spring Balance.

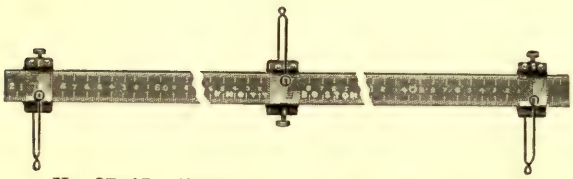
Complete apparatus with Spring Balance **$1.45**

SEPARATE PARTS

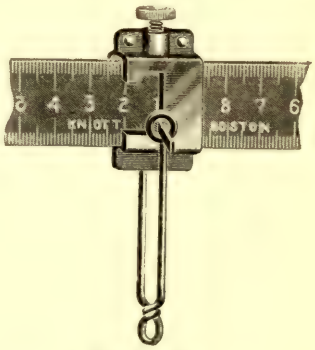
27–11 WHITE WOOD STRIP, 50 × 20 centimeters . . . . . **.45**
27–12 WOODEN BLOCK, 7.5 centimeters square . . . . . **.20**
15–300 SPRING BALANCE, 250 grams and 8 ounces . . . . . **.80**
27–30 DEMONSTRATION LEVER, illustrating simple balance and also for experimental use as a lever of the first, second, or third class.

This instrument consists of a Knife Edge Hanger which, in use, clamps about the Meter Stick, acting, in balance demonstration, as the central knife edge and in lever experiments as the fulcrum. A forked metal casting with wide V planes for the Knife-edge Support acts as the supporting base. Two of our No. **27–45** Kittredge Lever Clamps complete the apparatus. A pointer ingeniously attached to the central knife edge hanger makes possible the use of this apparatus as a balance for rough determinations.

Complete apparatus as illustrated including pointer but without Meter Stick **1.95**
27–31 SUPPORT BASE, only . . . . . **.90**
27–32 KNIFE EDGE HANGER without Pointer . . . . . **.27**
27–33 KNIFE EDGE HANGER with Pointer . . . . . **.55**



No. 27–45 (Showing Lever of the First Class)

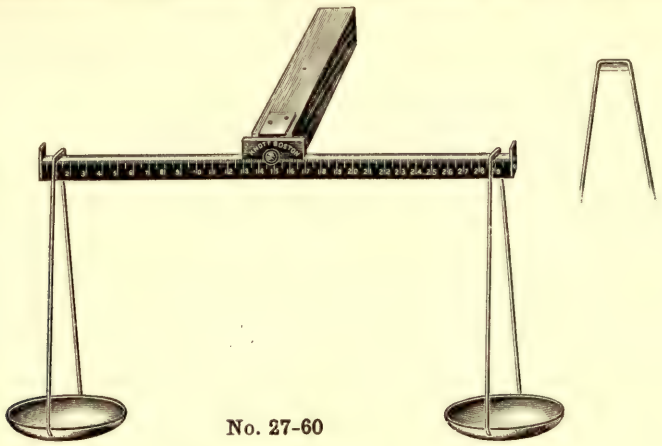


No. 27–45

27–45 KITTREDGE LEVER CLAMPS for use with an ordinary Meter Stick in determining the Mechanical Advantage of a Lever.

This little clamp has practically revolutionized apparatus for study of levers. Its simplicity and facility of operation has made it an extremely popular device.

This clamp is made up of two metal stampings riveted together to form of meter stick and which may be clamped to it by means of a thumb screw. A knife-edge protruding on each side offers a friction-less support for the loops of a stirrup for attaching weights or hook of the scale pan. Per set of Three **$0.81**

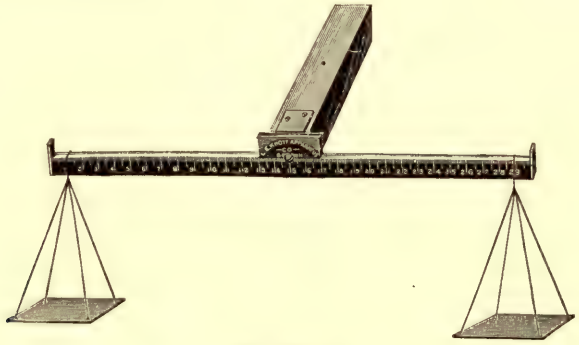


No. 27-60

27–60 LEVER APPARATUS for the study of Mechanical Advantages of a Lever.
The apparatus consists of a wooden bar to which is attached a graduated movable cross head with metal retaining ends. A pair of scale pans with improved knife edge bearings after Mr. W. F. Rice complete the apparatus. Complete as illustrated $1.20

27–61 LEVER AND SUPPORTING BAR only 45

27–62 RICE SCALE PANS . . . . . Per Pair .75



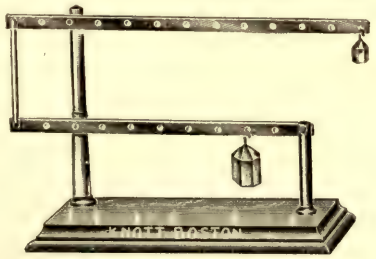
No. 27–65

27–65 LEVER APPARATUS for study of the Mechanical Advantage of a Lever.
This apparatus is the same as No. **27–60,** except the less expensive Scale Pans, attached by strings, are substituted.
Complete as illustrated $0.85

27–67 SCALE PANS, same as used in above, accurately adjusted to weigh one ounce . . . . . Per Pair .40

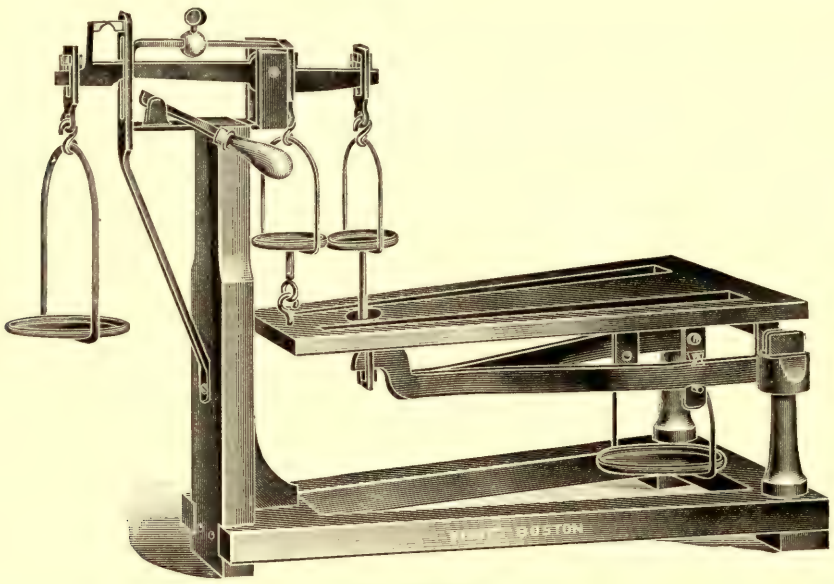
NOTE.—A Wheel and Axle is an example of a lever of the first class. Our Hortvet's Apparatus **No. 27-345,** is designed for the purpose of connecting the principles of levers and wheels.

27–75 RIDER BLOCK, for use on meter stick in determining Weight of Lever Arms.
This is a small block slotted to fit an ordinary meter stick and provided with a screw for fastening. Its use is described by Hall and Bergen's, "A Text-Book of Physics," Exercise **12** 18



No. 27–95

27–95 COMPOUND LEVER, illustrating a combination of simple levers to secure power equivalent to a simple lever with long arm.
The apparatus consists of two lacquered brass strips connected and mounted as illustrated on a convenient wooden base.
Without weights $4.50



No. 27–130

27–110 STEELYARD illustrating the practical application of the Lever of the First Class in a Weighing Beam. Capacity of steelyard, 50 pounds **$1.25**

27–130 WEIGH BRIDGE illustrating how the principles derived from the study of simple compound levers may be combined to practical value.

Our model, substantially constructed of wood and metal, is ample in size for lecture room demonstration. It is handsomely finished throughout, accurately constructed, and may be used with perfect safety up to 10 kilograms.

The teaching value of this instrument in the study of compound levers is further enhanced in that the instrument is a working model of a commercial weigh bridge with all working parts exposed, with all the most simple attachments that are fundamental in the commercial bridge . . Duty Free **16.25**

HARCOURT STEEL BALL-BEARING PULLEYS

See Illustrations next page

All of the following sets are made up of the well-known Harcourt Ball-Bearing Pulleys fully illustrated and described on the following page. Each set includes pulleys, stirrups, and axle rods sufficient for assembling any of the combinations as listed.

27–140 SIMPLE PULLEY ASSORTMENT, parts sufficient to assemble, —
4 Single Pulleys
2 Double Pulleys . . . . . Per Set **$2.80**

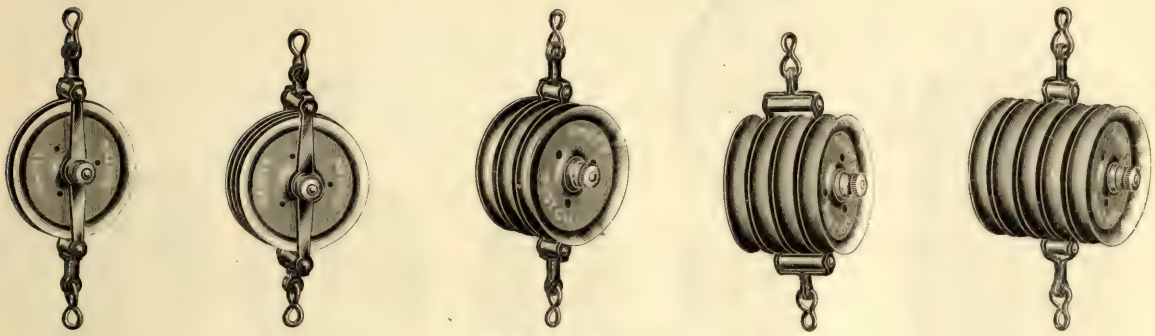
27–141 PULLEY ASSORTMENT, parts sufficient to assemble, —
6 Single Pulleys
3 Double Pulleys
2 Triple Pulleys . . . . . Per Set **4.40**

27–142 PULLEY ASSORTMENT, parts sufficient to assemble, —
8 Single Pulleys
2 Triple Pulleys
4 Double Pulleys
2 Quadruple Pulleys . . . . Per Set **6.00**

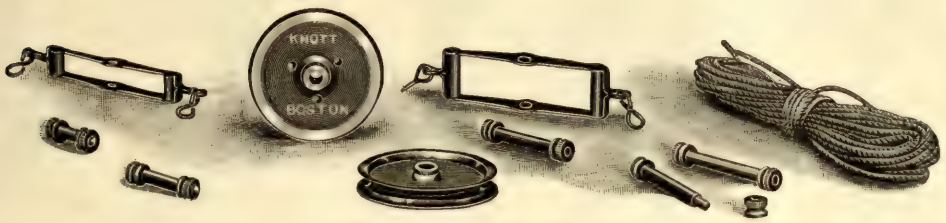
27–143 PULLEY ASSORTMENT, parts sufficient to assemble, —
12 Single Pulleys
4 Triple Pulleys
6 Double Pulleys
3 Quadruple Pulleys
2 Quintuple Pulleys . . . . . Per Set **9.00**

The above assortment, No. **27–143,** will be found adequate for study of the principal combinations of pulleys in deriving mechanical advantages of the same. It is, therefore, highly recommended as a lecture-table demonstration assortment.

PULLEYS



Nos. 27-150 to 27-158



Nos. 27-165 to 27-185

A PULLEY is one of the most essential requisites in the study of Mechanical Powers. The attainment of results where guesswork is not required for the formulation of the laws has been confined largely to a class of instruments not within the reach of the appropriation of many educational institutions. In many of the pulley experiments as conducted in these institutions today, the student cannot be blamed for the inaccuracies of his conclusions. Our experience has advised and our experimentation has designed our present **BALL-BEARING FRICTIONLESS PULLEY,** which we can heartily recommend. It has the further quality of **Expansion Possibilities,** in that, with a basis of the single unsheaved pulley and with the addition of an outfit of axles and stirrups, any combination up to two pulleys of five sheaves is possible.

Our **BALL-BEARING FRICTIONLESS PULLEY** is shown in detail in the lower part of our illustration, and various sheaves are pictured in the upper part.

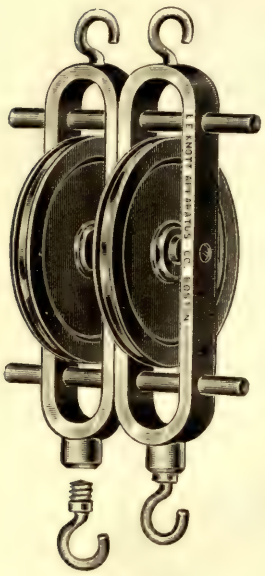
By inspection of the single pulley without stirrup, the face and edge of which are both shown, it will be noted that this pulley is made up of two parts, each stamped out of one piece of metal by means of expensive tools and dies. Both are then riveted firmly together with ball race in place. In assembling, it is only necessary to use the metal stirrup, stamped and formed also by tools and dies, and to attach to pulley by means of the shortest axle illustrated. No tools are required, as all attachment is secured by two thumb nuts. In assembling a sheave of two or four pulleys, the wider stirrup is used with the longest axle rod. In assembling a sheave of five pulleys, the narrow stirrup is used with the longest axle rod.

Each Pulley with all parts is neatly nickeled and stirrup is provided with double hooks. For convenience in purchasing, we list assembled sheaves. When experimenting with these pulleys, we desire to urge upon our patrons the necessity of using a cord of about 1/16 inch diameter.

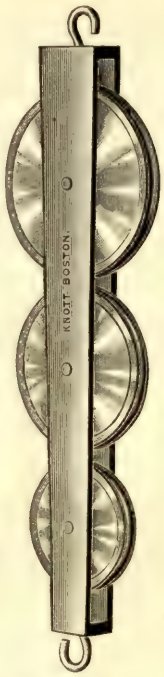
27-150	**Single Ball-Bearing Frictionless Pulley**	Each	**$0.55**
27-152	**Double Ball-Bearing Frictionless Pulley**	Each	**.85**
27-154	**Triple Ball-Bearing Frictionless Pulley**	Each	**1.15**
27-156	**Quadruple Ball-Bearing Frictionless Pulley**	Each	**1.45**
27-158	**Quintuple Ball-Bearing Frictionless Pulley**	Each	**1.75**

SEPARATE PARTS

27-165	**Ball-Bearing Pulley**	Each	**$0.30**
27-167	**Axle Rod for Assembling Single Pulley**	Each	**.08**
27-169	**" " " " Double Pulley**	Each	**.08**
27-171	**" " " " Triple Pulley**	Each	**.08**
27-173	**" " " " Quadruple Pulley**	Each	**.08**
27-175	**" " " " Quintuple Pulley**	Each	**.08**
27-177	**Stirrup for Assembling Single, Triple and Quintuple Pulleys**	Each	**.20**
27-179	**Stirrup for Assembling Double and Quadruple Pulleys**	Each	**.20**
27-185	**Pulley Cord,** especially adapted for all pulley experiments. This cord is of extra quality hemp, 1/16 inch diameter	Per hank of 5 yards	.20



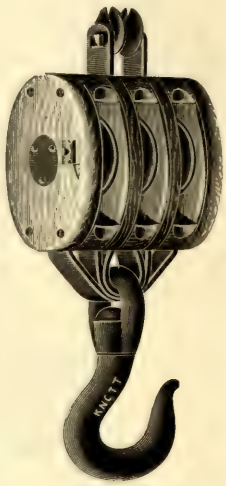
No. 27–200



No. 27–215

No. 27–230a

No. 27–230b



No. 27–230c

27–200 LATHE TURNED PULLEY, a frictionless running, brass pulley, 2½ inches in diameter, mounted in heavy brass frame on hardened steel cone bearings. Each pulley is carefully turned, centered in a lathe, and, therefore, when mounted runs absolutely true and is in true balance. The rim is turned with square groove that accurate measurement of diameter may readily be secured. Both ends of the frame are provided with hooks one of which may be removed from the frame and replaced by any rod tapped ¼ × 20 (See No. **5–10**). Different combinations as illustrated are possible by use of a pair of steel rods.
All parts handsomely nickel-plated . . . . . Each Pulley **$2.25**

27–201 STEEL RODS for use in making combinations of above Lathe Turned Pulley . . . . Per Pair **.10**

27–215 TRIPLE TANDEM PULLEY for comparison of the Mechanical Advantages of Pulley Arrangement. Each tandem pulley consists of three pulley wheels of different diameters mounted in cone bearings in a metal frame. Each pulley is lathe turned, carefully mounted and adjusted . . . Per Pair **1.90**

27–216 ——, same as above, but singly . . . . . **.95**

No. 5–950

No. 5–952

5–950 PULLEY ON ROD, axis at right angles to rod **$0.94**

5–952 PULLEY ON ROD, axis in same plane as rod . . . . . **.90**

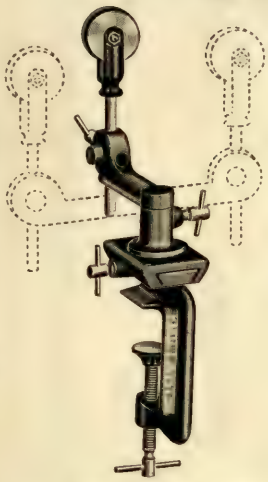
TACKLE BLOCKS (HARCOURT'S PATENT). These commercial pulleys must not be confused with inexpensive types. They are carefully made from lignum-vitae with self-lubricating iron bushings. Each shell is provided with a swivel hook and becket.

27-230 TACKLE BLOCKS, size of sheave 2¼ × ⅝ × ⅜ inches; length of shell, 4 inches; requires rope ½ inch diameter.

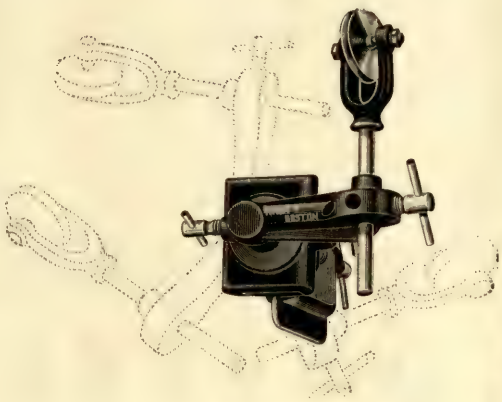
	a	b	c
	Single	Double	Triple
Each	**$1.70**	**$2.10**	**$2.85**

27–235 MANILA CORDAGE, ½ inch diameter, as required with above Tackle Blocks. This rope is constructed of only the best quality of manila hemp. Sold only in multiples of 10 feet. Per 10 Feet **.25**

No. 27–240



No. 27–250 (Front View)



No. 27–250 (Top View)

No. 27–242

27–240 DIFFERENTIAL PULLEY HOIST, for illustration of and determination of mechanical advantage of a commercial differential pulley hoist.

This Hoist is carefully made and thoroughly tested to the capacity of ¼ ton before shipping. Only the best of hand-made chain is used, and careful attention to all details makes this a safe instrument under full capacity and of an accuracy which would class under Scientific Apparatus. Regular hoist, 6 feet; minimum distance between hooks, 17 inches; weight, 22 pounds; capacity, ¼ ton; chain pull, 72 pounds through 18 feet **$17.50**

27–242 DIFFERENTIAL PULLEY HOIST, smaller model with brass pulleys, mounted on stand. Duty free **8.25**

27–250 T-BEAM UNIVERSAL PULLEY. This pulley is one of our Harcourt Universal T-Beam Series, and we justly claim for it advantages that can only be realized when once used. The table clamp is our **5–1000** Basic Clamp "**A.**" Attached adjustably to the beveled slide of this clamp is our Universal Pulley Interlocking Attachment No. **5–1080.** This attachment consists of two castings, the interlocking base provided with a nickel-plated T-screw for fixing to the beveled slide top of the basic clamp, and a pulley arm which swivels about the post of the interlocking base. As may be noted, this arm may be firmly locked by the T-screw in the post. At the end of the pulley arm, cast as a part of the arm, is a circular block in which are drilled a number of holes in any of which the pulley rod may be locked by a T-screw.

The pulley itself is of careful construction and is mounted on cone bearings in a stirrup which is attached to the rod.

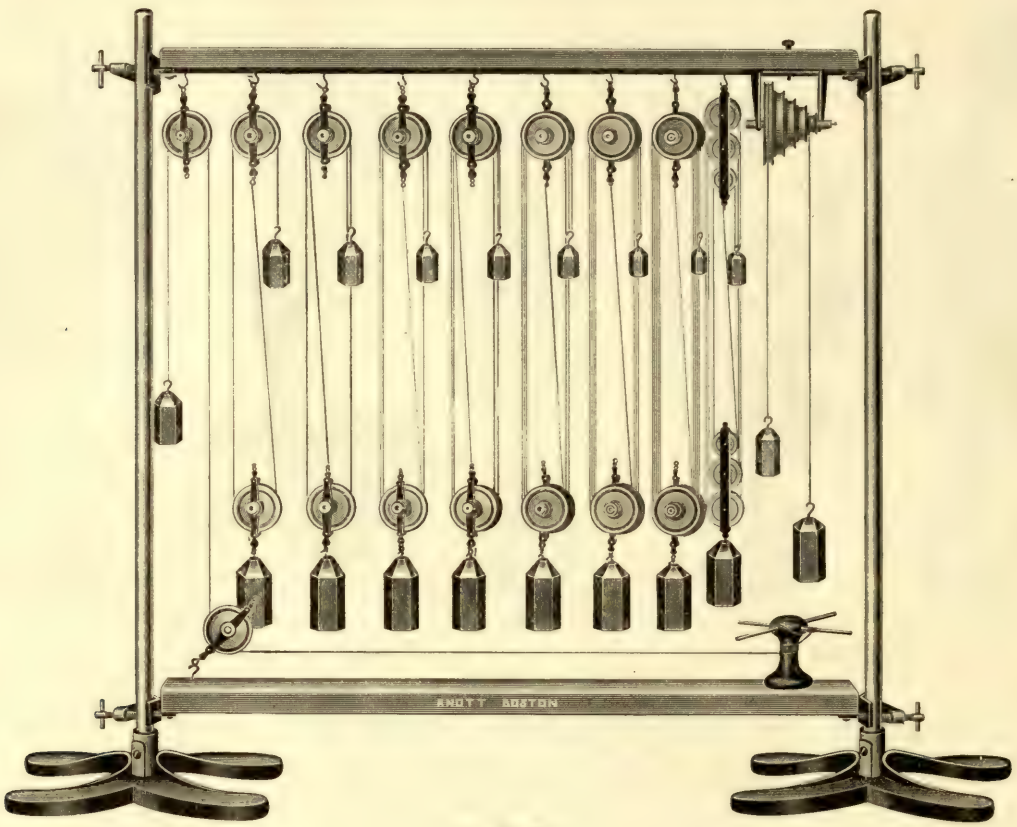
We claim for our design a possibility of adjustments never heretofore attained by any design; in addition, a greater ease and rapidity in securing multitudinous positions. We also secure a backward and forward movement along the beveled slide. All positions may be firmly locked by the nickel-plated T-screws.

T-beam Universal Pulley, complete as illustrated **2.90**

Persons equipped with Universal T-beam Basic Clamp "**A**" need purchase only Interlocking Attachment.

5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "A" $1.15

5–1080 UNIVERSAL PULLEY INTERLOCKING ATTACHMENT 1.75



No. 27–275

27–275 PULLEY DEMONSTRATION APPARATUS. The frequent call for a complete outfit for demonstration of pulleys and the application of the principles thereof to wheels and axles and capstans has led us to design and assemble the above-illustrated combination.

As may be noted, the instrument consists of two upright rods mounted on our new-form H-base connecting these upright rods on two cross-bars provided with special clamps for attachment to the rods. To these cross-bars are attached the various combinations which can be assembled from the outfit listed below.

The apparatus as above illustrated is furnished complete with all accessories as follows,—

A Complete Equipment of Pulleys for Illustrating:

Fixed pulley, weight and power equal.

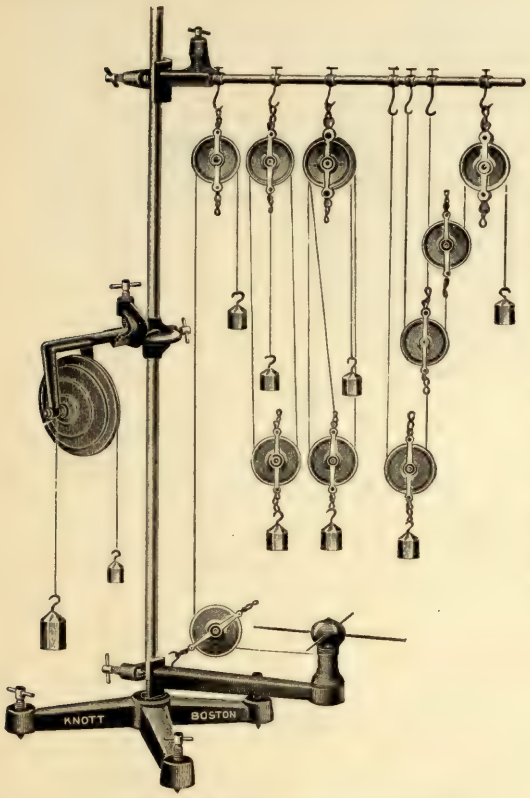
Fixed and movable pulleys for securing the following combinations: weight and power as 1:2; 1:3; 1:4; 1:5; 1:6; 1:8; and 1:10.

These pulleys are the Harcourt Steel Ball-Bearing Pulleys (See page 141), an outfit being supplied capable of giving any of the combinations above desired, thus one may secure quintuple, quadruple, triple, double, and single pulleys in various combinations.

Improved Wheel and Axle, 5 diameters which are based upon simple weight ratios.

Capstan and Lever. 1 pair triple tandem pulleys.

Apparatus complete without weights **$18.40**



PULLEY STUDY APPARATUS

PULLEY STUDY APPARATUS

The only distinctive item required for "set up" illustrated is as follows:

27–290 **CAPSTAN ARM** with **CAPSTAN.** This is a special casting with clamp and arm in one piece. At the end is mounted a capstan . **$2.15**

Apparatus above illustrated, elsewhere listed.

5–770 **RIGHT ANGLE CLAMP** . . . . . **.95**

22–131 **TRIPOD AND BASE** **3.00**

5–645 **HOOK COLLARS** (4 needed) . . . . Each **.22**

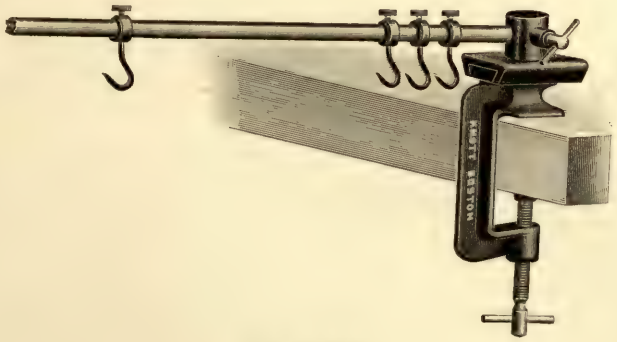
27–150 **BALL-BEARING SINGLE PULLEYS** (4 needed) . . . . . **.55**

27–152 **BALL-BEARING DOUBLE PULLEY** . . . **.85**

27–325 **WHEEL AND AXLE** **1.45**

NOTE: Our **No. 22-130** Tripod Support without leveling screws may be used if desired in place of the one illustrated.

WEIGHTS. Section **16.**

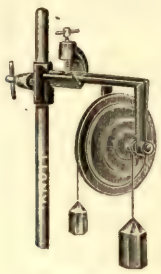


No. 27–300

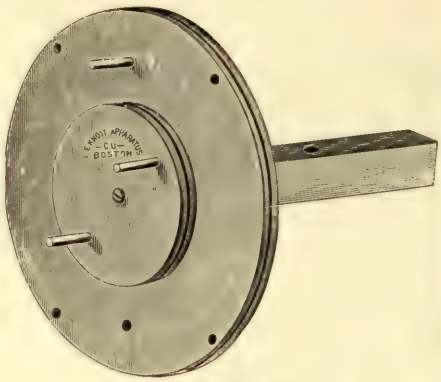
27–300 **CROSS-BAR ATTACHMENT** for clamping to the cross-bar of the Standard Physics Table as support for hanging Pendulums, Pulleys, etc.

This apparatus consists, as may be seen from the illustration, of a combination of our T-Beam Series with rod and hook collars.

Complete as illustrated with four collars **$2.95**



No. 27–325



No. 27–335

27–325 FIVE DIAMETER WHEEL AND AXLE, for attachment to support rod by means of a clamp, in determining the Mechanical Advantage of a Wheel and Axle.

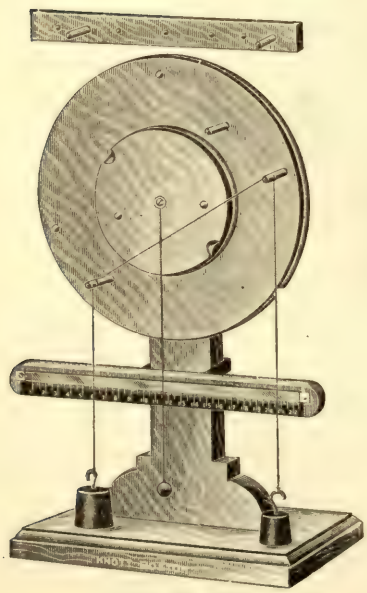
This Wheel and Axle is made from new specifications which have been figured on the basis of simple ratios. It is made of mahogany wood, nicely finished, with 5 diameters. It is mounted in cone pivots in a metal frame attached to a ½ inch rod for use in clamp.

Without Clamp **$1.45**

The Clamp above illustrated is **5–770 RIGHT ANGLE CLAMP** . . . . . **.95**

27–335 WHEEL AND AXLE, after Hall & Bergen's "A Text-Book of Physics," paragraph 64, for determining the Mechanical Advantage of Wheel and Axle; also provided with attachments showing that the Wheel and Axle is simply a modified lever of the First Class.

This apparatus consists of two wooden discs combined in one piece attached at its center to a wooden rod by means of a screw, about which it is free to move as an axle. This wooden rod is devised for clamping to the cross beam of the Standard Physics Table or other convenient means of support. At various points on the disc are drilled holes to which cords may be attached by use of brass pins thrust into them . . . . . **.95**



No. 27–345

27–345 HORTVET'S APPARATUS, illustrating that the Mechanical Advantage of the Wheel and Axle is the same as that for the Lever of the First Class; also for demonstrating principles of both machines which are not possible with the simplified apparatus.

This apparatus consists of an upright wooden stand, vertically supported on which is a disc of wood having 2 diameters. At various convenient points on this disc are drilled holes into which brass pins may be thrust for support of cords which, suspended from these pins, answer the double purpose of attaching weights and of supplying a plumb line for measuring the diameters of the two discs or of lengths of the "Power" and "Weight" Arms, the readings being taken from the plumb line dropped from the center axle. Just below the disc, attached at right angles to the upright, is a cross head which bears a scale and a narrow mirror which obviates in reading errors due to parallax.

Experimental work on Levers, with fulcrum below or above line of support of "Power" and "Weight," is one of the features of this instrument not possible on instruments of simple form. Many other interesting problems are possible with this apparatus.

Apparatus complete as illustrated with the addition of a simple Lever which may be attached in place of the disc on the upright **7.25**

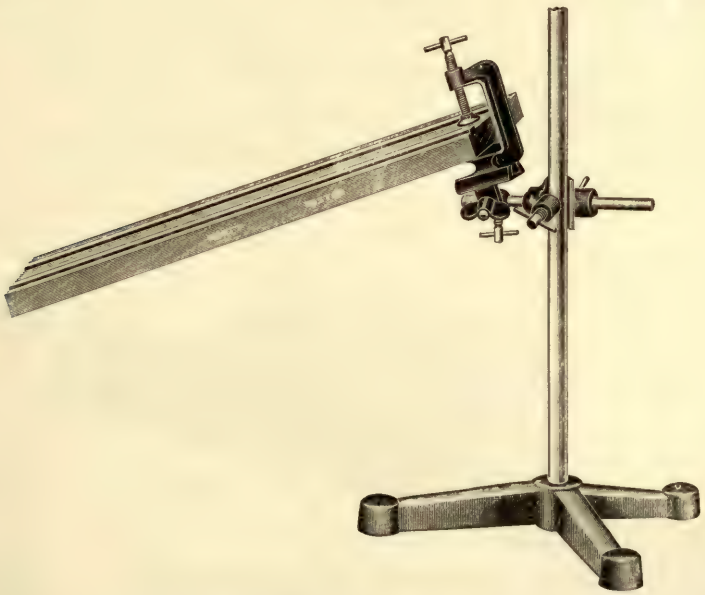
27–360 MECHANICAL POWERS APPARATUS for determining mechanical advantage of simple machines such as the lever of the first, second, or third class, the wheel and axle, and the pulley.

The apparatus consists of a well-balanced lever arm provided with a brass central piece with holes through which may be thrust the fulcrum pin on which lever may be supported on the forked support in demonstrating an equal arm lever of the first class. A second hole provided in this brass piece serves to illustrate the effect of raising or lowering the center of oscillation. The illustration shows method of securing levers of the second and third classes, the second class being the one illustrated.

The forked stand is also for use as a support for the wheel and axle (two being illustrated above, but one only being furnished). The weight is supplied by means of special forms of double-hooked brass weights, ten of which are furnished with each outfit.

Apparatus complete as illustrated, including one forked stand, one lever bar, one wheel and axle, support rod and round base, one clamp and arm, one ball-bearing single pulley, one stirrup, a scale pan, and ten double-hooked weights **$7.65**

No. 27–360



ADJUSTABLE INCLINED PLANE SUPPORT

The above illustration shows method of assembling an adjustable support for securing various inclines for a plane. All parts entering into the support are previously listed and if already in the school equipment need not be purchased.

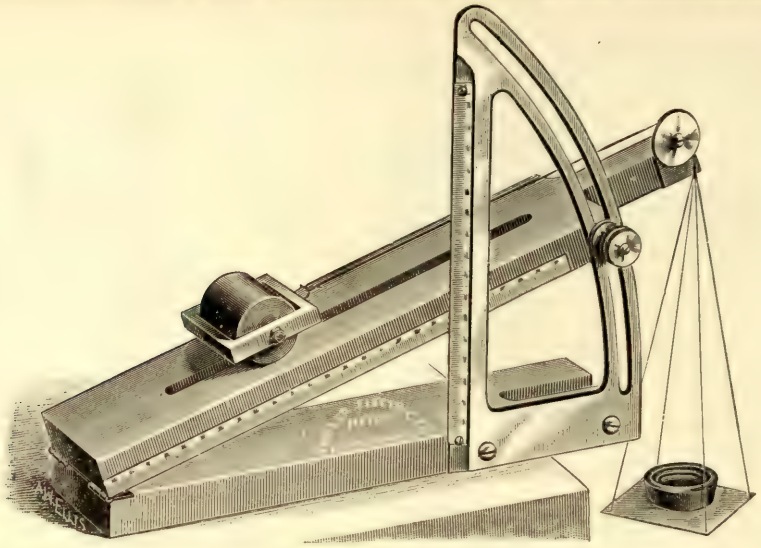
The parts are as follows:

5–1000	**UNIVERSAL T-BEAM BASIC CLAMP "A"** .	**$1.15**
5–1035	**SWIVEL POST ATTACHMENT**	**.74**
5–15a	**SUPPORT ROD**	**.25**
5–730	**RIGHT ANGLE CLAMP**	**.65**
22–130	**UNIVERSAL STAND**	**2.00**

27–390 INCLINED PLANE WITH SIDE RAILS. This plane, illustrated above, is a neatly finished close-grained wooden plank provided with side ledges. It is 120 centimeters long and 15 centimeters wide. It is furnished with screw adjustment for comparison of masses by the acceleration test. (See Hall & Bergen's "A Text-Book of Physics," Exercise **36**) **$1.60**

27–392 INCLINED PLANE, after Millikan & Gale's "A Laboratory Course in Physics," Experiment **16.** This plane is a smooth hardwood surface, 5 inches wide, 4 feet long . . . . . **.75**

27–393 PULLEY IN FRAME, as used in above, for attachment to any board . . . . . **.75**



No. 27–402

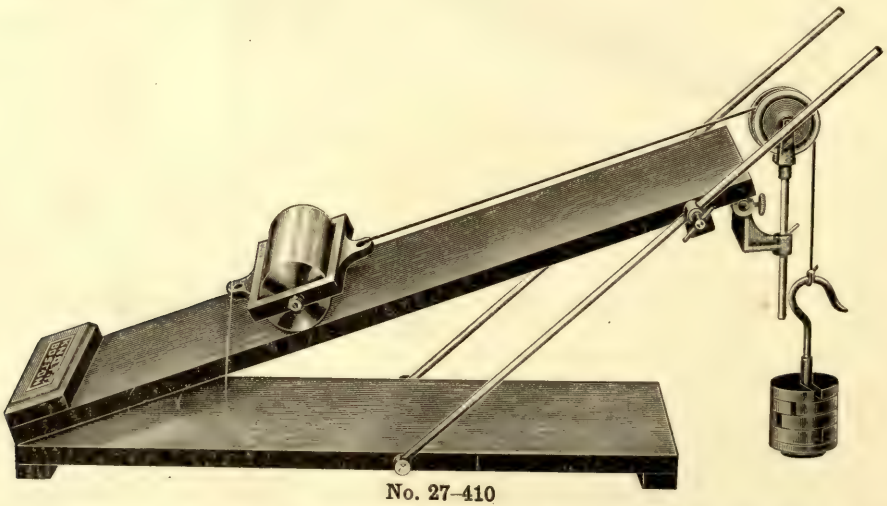
27–400 **HALL'S INCLINED PLANE APPARATUS,** for determining the mechanical advantage of the inclined plane.

This apparatus consists of a wooden base to which is hinged a board whose surface is carefully smoothed and finished. This board may be inclined at any desired angle as indicated by the graduated metal arc and set to same by means of a knurled head. "Power" and "weight" are balanced over a freely running pulley set in pivotal bearings. Graduated scales for both incline and height.

Plane only, without illustrated scale pan, roller, and weights $4.45

27–402 ——, same as above but is provided with a roller as above illustrated, adjusted to weigh exactly one pound. It is also furnished with the scale pan but without weights 6.60

WEIGHTS. Section **16.**



No. 27–410

27–410 **PRATT INSTITUTE INCLINED PLANE,** for determining mechanical advantage of an inclined plane.

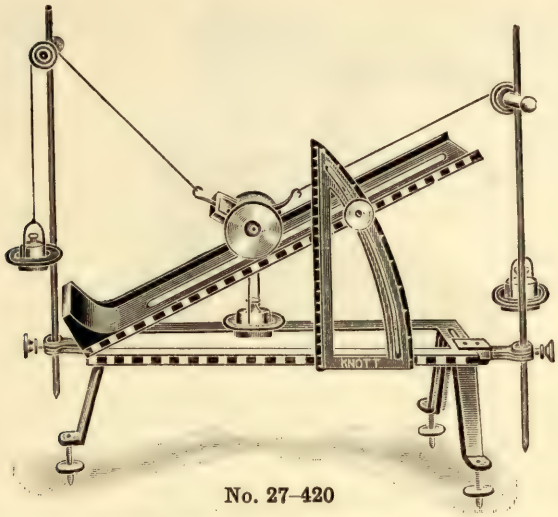
This apparatus, manufactured by us, consists of two hinged boards of close-grained hardwood, the upper surface of which is carefully planed and finished smooth. The variable inclines are secured by means of the swiveled brass rods which may be locked in any position desired. "Power" and "weight" are balanced over a ball-bearing single pulley on rod, adjustably mounted in a special bracket casting. For the "power" it is designed that the roller illustrated above and weighing 11 pounds be used; for "weight," hanger and weights illustrated and described in section **16.**

Inclined Plane only, without illustrated weights, hanger, or roller $7.35

27–412 **PRATT INSTITUTE INCLINED PLANE ROLLER.** This roller as above described weighs 11 pounds. The surface is carefully turned and is mounted in a frame in pivotal bearings. Although designed especially for use with the above inclined plane it may be used to advantage on any incline whatsoever.

Roller only, as above illustrated 3.15

WEIGHTS. Section **16.**



No. 27–420

27–420 WEINHOLD'S DEMONSTRATION INCLINED PLANE for the quantitative study of factors governing mechanical advantage of an inclined plane.

In this apparatus, with graduated arc, length, height, and incline dimensions, not only may the Mechanical Advantage of an Incline be quantitatively determined, but also the normal pressure on the plane can be measured.

The apparatus consists of a frame, as illustrated, similar in appearance to any carefully constructed Inclined Plane. The roll, however, of this plane is provided with three stirrups for use as illustrated in measuring normal pressure on the plane, one component being determined by a mass hung over a pulley attached to the upright rod at the right, the other component, by the mass hung similarly at the left.

This plane is carefully constructed throughout, all parts being neatly finished.

Furnished complete as illustrated, but without weights of any kind . . . . . Duty Free **$28.45**

No. 27–435

27–430 ROLLER FOR INCLINED PLANE for use as the " Weight " in determining the Mechanical Advantage of the Inclined Plane.

Consists of a carefully turned brass roller, ends centered and pivoted in metal frame. **$1.95**

27–435 INCLINED PLANE CAR for use with weights as the " Weight " in determining the Mechanical Advantage of the Inclined Plane.

In this car we have attempted to obviate the errors of the ordinary four-wheel type, and use a car with three wheels only, thus securing positive wheel action on all three wheels.

The body of this car is a metal casting, neatly finished in japan; the wheels, mounted in frictioniess cone bearings, are lacquered brass. A hook for attaching the power is also provided **1.55**

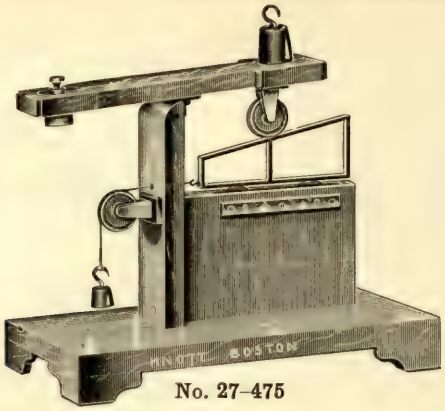
27–440 INCLINED PLANE CAR, ordinary type with four brass wheels in pivotal bearings **1.10**

27–460 WOODEN SPREADER for experiments with an Inclined Plane when it is desired to use " Power " parallel to base.

This consists of a rod, which, by means of a set screw, can be attached to the front end of the car. As this rod extends beyond either edge of the ordinary width Inclined Plane, cords from the " Weight " can readily be attached.

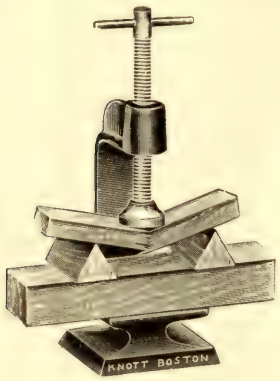
When there is no slot lengthwise of the incline, this spreader will be found a great convenience . . **.10**

27–465 RUBBER CORD for use in experiments with an Inclined Plane Car on Inclined Plane in Inertia Experiments, as described in Hall & Bergen's " A Text Book of Physics," Exercise **36** . . Each **.20**

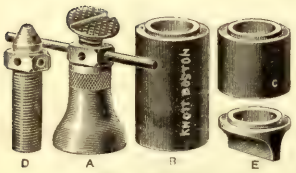


No. 27–475

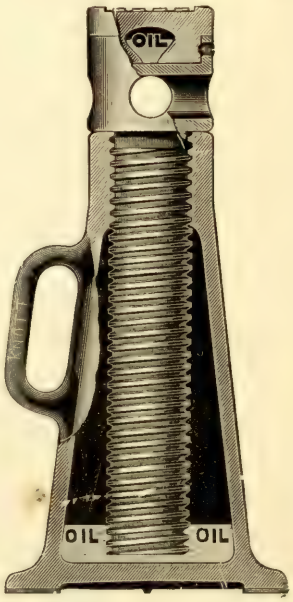
27–475 MODEL OF WEDGE for determining the Mechanical Advantage of a Wedge.
This apparatus consists of a wedge-shaped metal skeleton which in operation is held between three easily running pulley wheels supported above and below the wedge. " Power " is attached by means of a cord over the fourth pulley illustrated. " Weight " is supported from above on hinged platform.
Complete without weights **$8.25**
WEIGHTS, see Section **16.**
27–485 WEDGE consisting of a two-part piece of hard wood, 18 centimeters long, each part 2½ centimeters at point of greatest thickness . . . . . Each **.80**



No. 27–500



No. 27–510



No. 27–520

27–500 MODEL OF A SCREW for the qualitative illustration of the great force of a screw. The design above pictured illustrates the tremendous power that may be secured by means of a screw.
This design consists of a modification of one of our T-Beam designs, the modification consisting of a special casting attachment with breaking wedges securely fastened to the face of our Basic Clamp " B " **$2.15**
27–510 JACK SCREW, demonstrating the Mechanical Advantage of the Screw; also used for leveling-up purposes.
This Jack Screw is 1¼ inches in diameter at the base and has a range from 2¼ to 3⅝ inches. By use of extension bases B and C, a range of from 2¼ to 6½ inches is possible. An auxiliary pointed screw D is supplied which may be used in place of the screw with swivel cap when it may be desired. The base E is also provided for use in special cases.
Jack Screw complete as illustrated, including A, B, C, D, and E **1.85**
27–510A JACK, only **1.00**
27–510B EXTENSION BASE, 2 inches high . . . . . **.30**
27–510C EXTENSION BASE, 1 inch high . . . . . **.20**
27–510D EXTENSION SCREW . . . . . **.20**
27–510E EXTENSION BASE . . . . . **.20**
27–520 CHAPMAN JACK SCREW, a practical Jack Screw adapted as a working model.
These screws are self-lubricating, the cap being provided with an oil chamber which supplies oil continuously, keeping threads oiled even when not in use, thus preserving the instrument from rust deterioration. Screw diameter 1¾ inches; range from 8 to 11¼ inches **4.30**

MODELS OF COMPLEX MACHINES

28 10 SIMPLE GEARED WHEELS, illustrating the great mechanical advantage of a system of geared wheels.

This system consists of two wheels with pinions, one-fourth the diameter of the wheels, while a third wheel has a drum of the same ratio, thus giving a mechanical advantage of 1 to 64. Gears mounted on rod for clamping to a support. Apparatus as illustrated shows use of our No. **5–770** Right Angle Clamp mounted on the rod of our No. **22–130** Universal Support.

Geared wheels only, without illustrated clamp $4.15

The clamp above illustrated is **5–770 Right Angle Clamp** 95

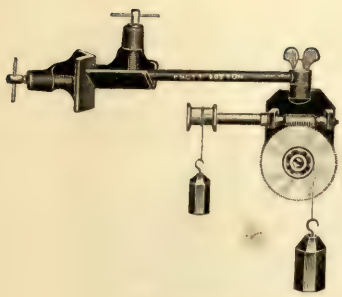
28–25 ENDLESS SCREW for determining the mechanical advantage of a gear operated by a screw.

This apparatus consists of a disc gear with drum for holding weight. This gear is actuated by an endless screw, one end of which terminates in a drum around which is attached the "power." The whole is mounted to a casting which is attached to a rod by a swivel joint which may be held fixed by a thumb nut. This rod may be clamped to any support by use of any right angle clamp, our No. **5–770** Clamp being illustrated.

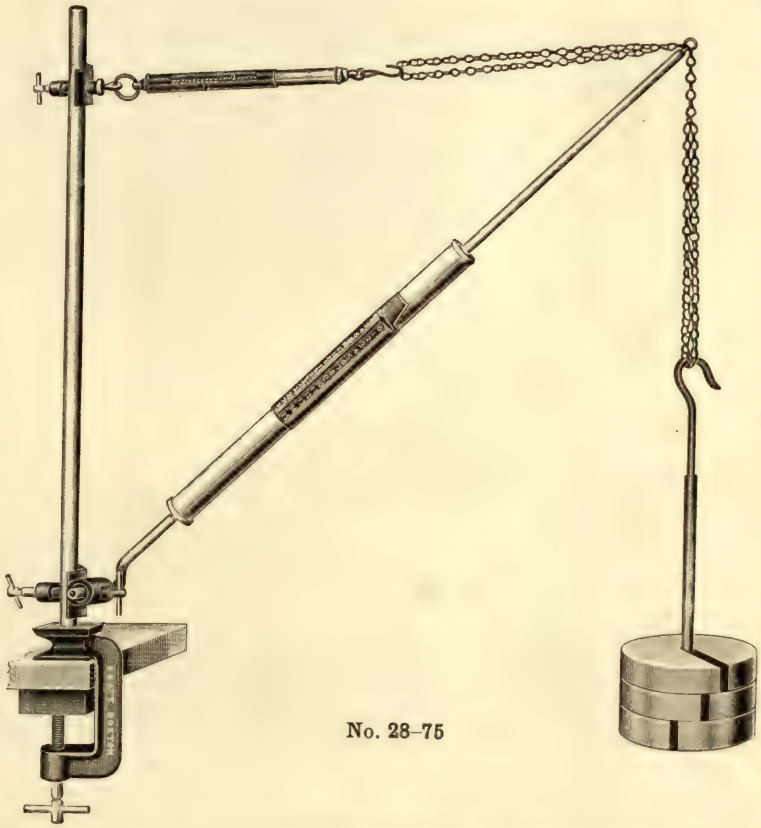
Endless screw only, without illustrated clamp 5.85

The clamp above illustrated is **5–770 Right Angle Clamp** 95

No. 28–10



No. 28–25



No. 28–75

28–75 CRANE DEMONSTRATION APPARATUS for quantitative demonstrations of boom stress and guy strains in cranes.

This apparatus consists of a boom devised to register all stresses in pounds or grams up to 30 pounds or 16 kilograms. It is shown illustrated with apparatus previously listed which, if already a part of the school equipment, need not be added.

The combination of this outfit allows a great latitude in determining the various factors entering into a commercial crane hoist. It is highly recommended by many technical schools and will be found a valuable acquisition.

Crane Boom only, with attached chains $7.25

28–78 THREADED HOOK, threaded ¼ × 20, for use with No. **5–785** Right Angle Clamp as illustrated .15

28–80 SPRING DYNAMOMETER, registering 20 pounds 1.25

Other apparatus above illustrated but previously listed is as follows:

5–1150 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "B" 1.90

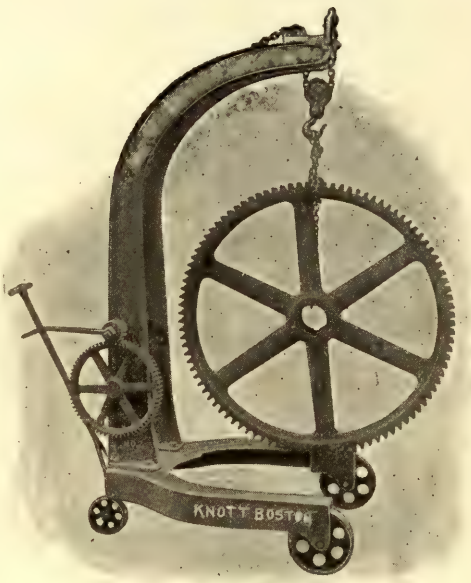
5–730 RIGHT ANGLE CLAMP 65

5–785 RIGHT ANGLE CLAMP 42

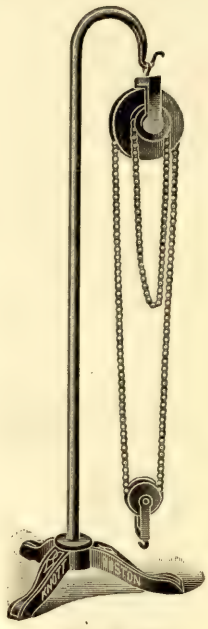
5–20e SUPPORT ROD, 19 millimeters diameter, 100 centimeters long 1.00

WEIGHTS. Section **16.**

No. 27–240



No. 28–100



No. 27–242

28–100 PORTABLE CRANE HOIST, used commercially in factories for raising and transporting heavy weights up to 1½ tons; may be used experimentally in the study of factors involved in the mechanics of a crane hoist.

From among the many Portable Crane Hoists on the market, we have selected this type as being the best adapted for educational institutions, possessing as it does many pedagogical superiorities over the other types.

Each machine has been designed with the object in mind of condensing the mass and the points of greatest strain; thus, the front axle of this model will bear a tensile strength of 60,000 to 70,000 pound per square inch. All pinions are strengthened by heavy shrouding and the metal in the bed-plate is much heavier at the end where the columns are joined on. Another feature of this crane is that the bed-plate is allowed, by means of a crank axle, to rest on the outside of the front wheels when the handle is thrown up, thus locking the crane in position. Each crane is easily transported from one position to another in that the bed-plate is provided with roller bearings.

This Crane Hoist is highly recommended in that it brings to the student an instrument in which all parts are comprised that may be found in the larger forms used in building constructions . . . **$74.00**

27–240 DIFFERENTIAL PULLEY HOIST, for illustration of and the determination of Mechanical Advantage of a Commercial Differential Pulley Hoist.

This Hoist is carefully made and thoroughly tested to the capacity of ¼ ton before shipping. Only the best of hand-made chain is used, and careful attention to all details makes this a safe instrument under full capacity and of an accuracy which would class under Scientific Apparatus. Regular Hoist, 6 feet; minimum distance between hooks, 17 inches; weight, 22 pounds; capacity, ¼ ton; chain pull, 72 pounds through 18 feet **17.50**

27–242 DIFFERENTIAL PULLEY HOIST, smaller model with brass pulley, mounted on stand. Duty Free **8.25**

PRATT INSTITUTE APPLIED PHYSICS APPARATUS

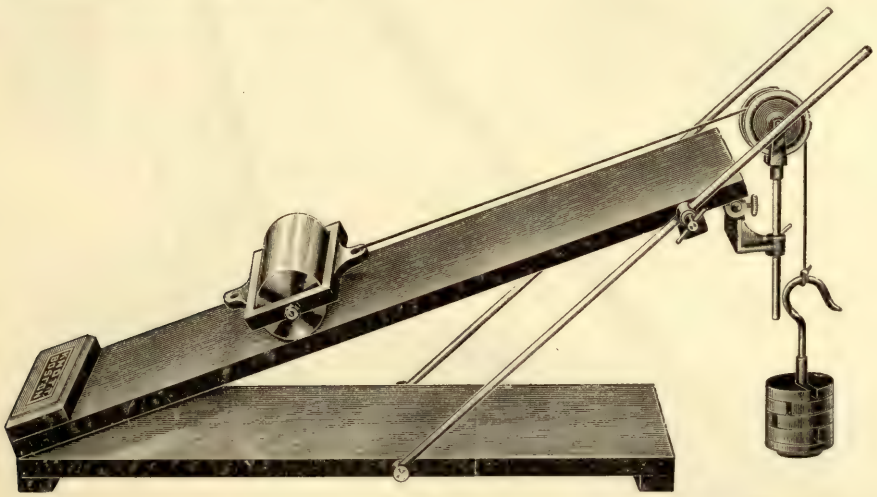
On the following pages is illustrated a line of apparatus as new to the scientific instrument houses as it is to educational laboratories in America. This line follows the designs as used in Pratt Institute, which have been worked out to meet the definite need of such work as is done at this institution.

The illustrations showing the line we are now offering were made from the pieces built for Wentworth Institute, Boston, under the immediate supervision of Prof. W. H. Timbie, Director of the Applied Physics Department.

Technical Schools, Trade Schools, Manual Training Schools, and High Schools giving vocational or manual training courses, will be interested in these pages.

DISTINCTIVE FEATURES. While some of the pieces in form, at least, will suggest the older types common in laboratory work, it must be noted that there is an essential difference, viz., *size.* All the parts are made *large* for a definite, pedagogical reason, the educational value of muscular reaction serving as the keynote of this work in Applied Mechanics.

The large crane, for example, will illustrate our point. This stands over seven feet high and is capable of handling a load of over 200 lbs. It at once impresses the student with its commercial importance and hence worthy of his serious attention. The design is such that notwithstanding that the commercial form has been maintained, every strain and reaction may be definitely determined and correct functions deduced.



No. 27–410

27–410 INCLINED PLANE. This instrument, when used in connection with the 11-lb. roller as illustrated, is well worked out for the study of,—

1st, Forces supporting a body on a frictionless surface.

2d, When used in connection with the Pratt Institute car, catalogue No. **27–435,** a study of the forces parallel to the incline may be made.

3d, When used with a friction block, catalogue No. **27–12,** the determination of the coefficient of friction by the two more common methods is readily made.

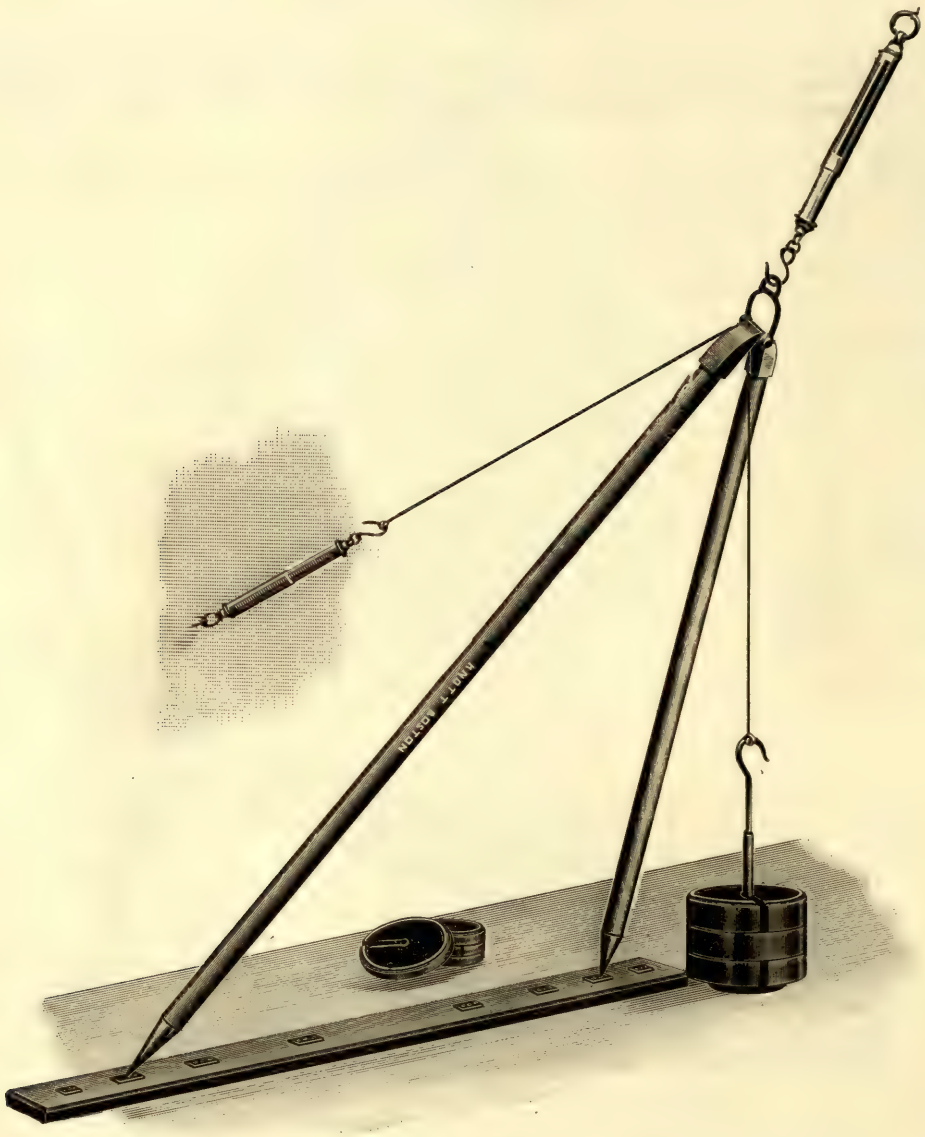
By the use of this plane all of the above problems may be solved in a more effective way than with the plane usually furnished.

Inclined Plane as listed, without weights, hanger, and roller **$7.35**

27–412 ROLLER, accurately centered and finished, weight 11 lbs. **3.15**

27–435 PRATT INSTITUTE CAR of accurate construction and correct design **1.55**

HANGERS AND WEIGHTS. Sect on **16.**



No. 29–30

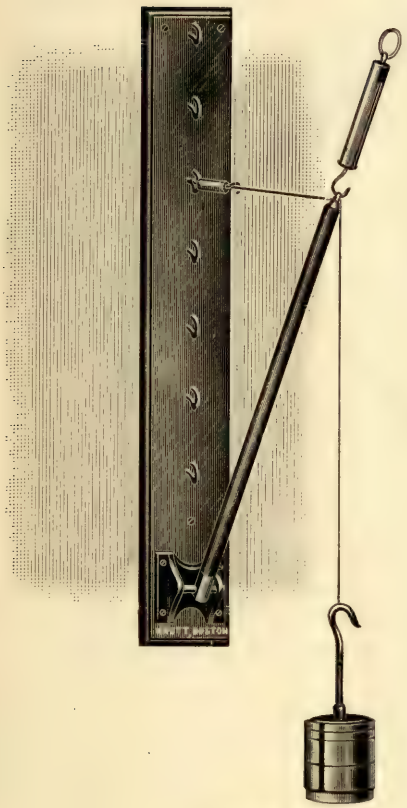
29–30 SHEAR LEGS. A most impressive illustration of the composition of forces as applied to the shear legs, solving definitely the following:

1st. The tension in the tie.
2d. The compression in the legs of shears.
3d. The forces necessary to keep the legs from spreading.

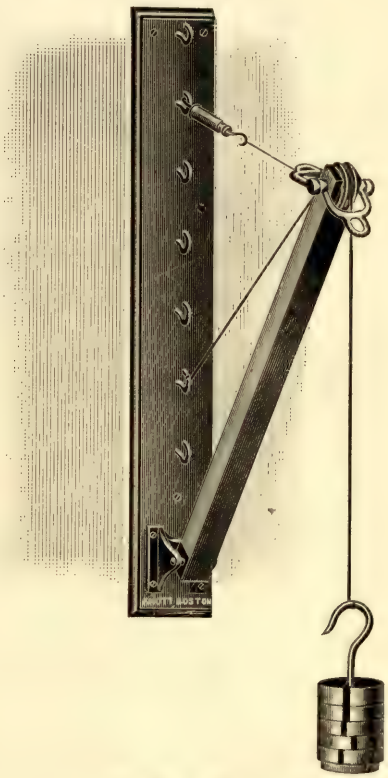
Made of seamless tubing, correct design of hinge so that every force is exerted at its proper point.
Price complete, without balances, weights, or hanger **$5.40**

29–40 SPRING DYNAMOMETER, registering 60 pounds **2.75**

HANGERS AND WEIGHTS. Section **16**



No. 29–60



No. 29–80

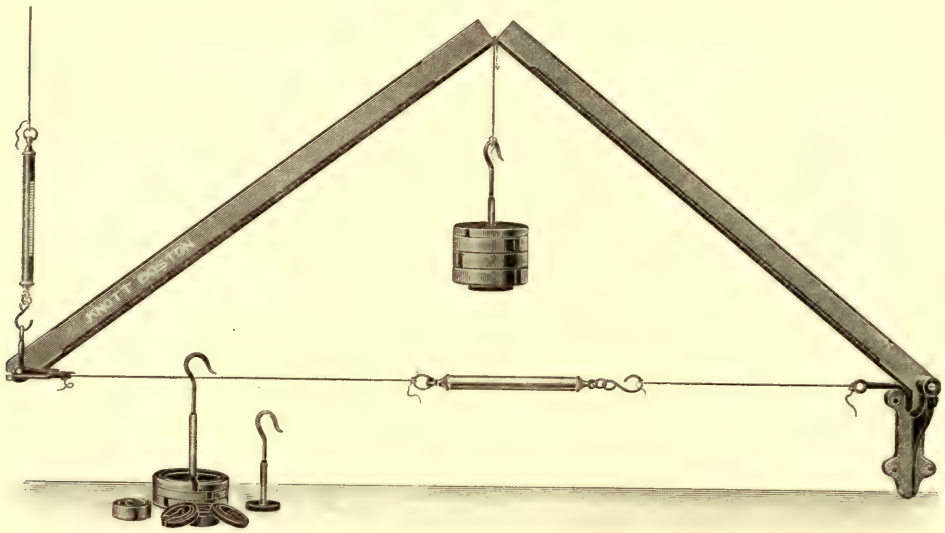
29–60 SIMPLE TRUSS. This simple apparatus serves to teach in the most direct manner possible, forces in the **Simple Stick and Tie.** The angle of inclination and load may be varied at will and the component forces at each angle accurately determined. When the angle of the Truss is increased to 90 degrees, the problem is even more interesting to the student.

Price, without Balances and Weights **$2.85**

29–80 SMALL HOISTING CRANE. A substantial, but simply designed apparatus for determining both the tension and compression in the **Hoisting Crane.** In this exercise the weight of the boom, which is material, should be taken into consideration.

Price, without Balances and Weights **3.85**

28–80 SPRING DYNAMOMETER, registering 20 pounds **1.25**



No. 29–100

29–100 ROOF TRUSS. The Laws of Equilibrium, as manifest in the simple Roof Truss, are strikingly solved with the above apparatus. Note that the pressure at every point is definitely measured. The support for holding the Truss against the side of the wall is so designed that the Truss may be loaded with a block of iron of uniform size, resembling pressure or strains made by the **snow load** or the **wind pressure load** on the roof.

Price of parts complete as illustrated, without Balance, Weights and Hangers **$4.25**

29–40 SPRING DYNAMOMETER, registering 60 pounds **2.75**
HANGERS AND WEIGHTS. Section **16**

LARGE HOISTING CRANE OR DERRICK

(For illustration, see following page.)

29–125 LARGE HOISTING CRANE OR DERRICK. The cut will show at a glance the method of determining the various forces, such as:

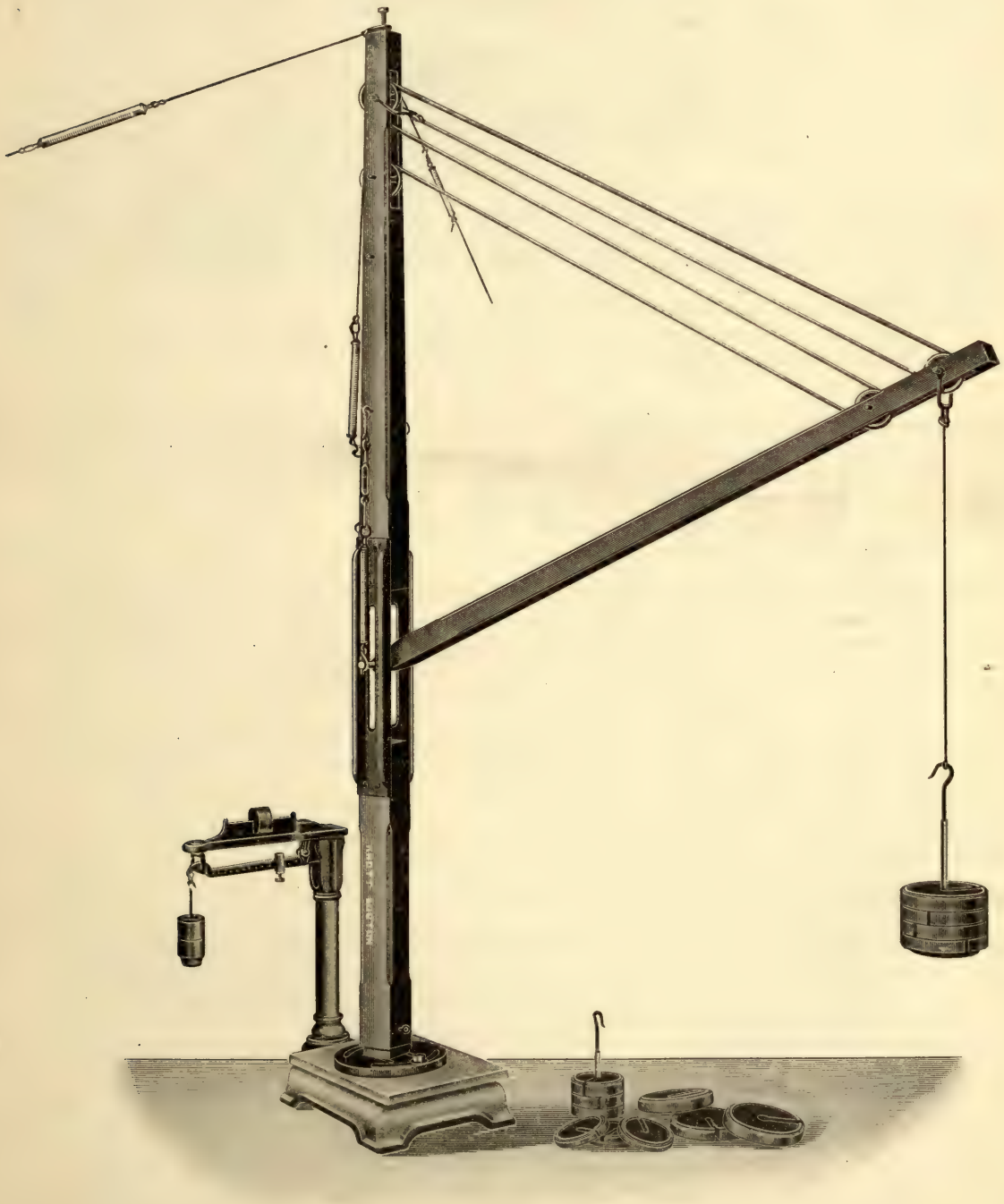
1st. The tension in the tie.
2d. The vertical and horizontal forces exerted by a boom against the mast.
3d. The amount and direction of the total force of the boom against the mast.
4th. The tension in each guy rope.
5th. The vertical and horizontal floor reactions at the foot of the mast.
6th. The horizontal component of the forces in the guy ropes. Compare this with the horizontal reaction at the foot of the mast.

Complete without Platform Scale, Balances, and Weights **$18.75**

29–130 PLATFORM SCALE, as illustrated opposite **18.75**

29–40 SPRING DYNAMOMETER, registering 60 pounds **2.75**
HANGERS AND WEIGHTS. Section **16**

LARGE HOISTING CRANE OR DERRICK



No. 29–125

See description on preceding page

PRATT INSTITUTE APPLIED MECHANICS APPARATUS

NOT ILLUSTRATED

The few pieces of Applied Mechanics Apparatus which we list, but do not illustrate, will be found of especial value in vocational and technical schools. The problems solved are of the greatest importance in engineering courses. The apparatus furnished is from designs found of great value in the work at Pratt Institute. These pieces are all in use by Prof. Timbie in his work at Wentworth Institute.

29–135 FORCES IN A UNIFORM METAL BAR 3 FEET LONG WITH SLIDING LOAD. With this apparatus the forces acting on a body supported by two cords not parallel, also by two cords parallel, may be definitely worked out **$7.50**

29–145 STEELYARD OF LARGE LABORATORY FORM. The apparatus is made from a uniform bar with measurable counterpoise and sliding weight. The apparatus is designed to be calibrated by the student according to the principles evolved in determining the center of mass in Uniform Bar Experiments **9.50**

29–155 WORKING MODEL OF THE ARCH. A four-foot model so designed that all the reactions and thrusts may be definitely determined.

1. The vertical reaction at the abutments.
2. The horizontal reaction at the abutments.
3. The horizontal force at the center of the arch ring.

Complete without Balances and Weights **10.00**

29–165 SCREW JACK WITH WHEEL, BASE, AND BAR. The efficiency test of the commercial screw jack has heretofore been considered out of the realm of laboratory work, even in Technical schools. The use of adequate load to represent real conditions has not been feasible except by this method found so successful in Pratt Institute.

With the apparatus the working load may be reckoned in **terms of tons,** while the power is in terms of **hundreds of pounds.**

The apparatus is made up of a supporting base, a self-oiling commercial jack of best quality, a power wheel 18 inches in diameter grooved for cord, a lever arm 8 feet long capable of sustaining the 2-ton load, and anchorage bar.

Complete without weights **28.50**

29–167 WEIGHTS for use with the above, unadjusted, in 50-pound units . . . . . Each **3.75**

29–169 HANGERS for weights, unadjusted, approximately 50 pounds . . . . . Each **5.25**

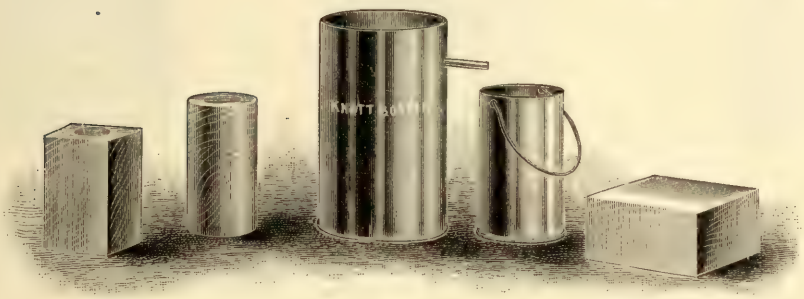
29–180 BENT-ARM LEVER AND SUPPORTING TABLE. This apparatus has been developed for the purpose of determining the relation between the forces acting on a lever. In its design special attention has been given to the eliminating of all directive forces due to gravity and friction, and enabling the use of forces of large dimensions.

Complete without Balances **27.50**

MECHANICS OF LIQUIDS

DENSITY AND SPECIFIC GRAVITY

No. 31–10



Nos. 31–18 to 31–27

No. 31–35

31–10 ARCHIMEDES' PRINCIPLE for demonstrating that a body submerged in water displaces an amount equal to its own volume.
This apparatus consists of a solid cylinder and bucket accurately machined so that the cylinder will exactly fit and fill the bucket. Each is provided with hooks and the bucket is further provided with a handle.
Polished and lacquered $1.65

31–18 OVERFLOW CAN AND CATCH BUCKET for formulating Archimedes' Principle. This apparatus consists of a nickel-plated spring brass Can with overflow spout near the top. The Catch Bucket, also of nickel-plated spring brass, is provided with a handle and is of convenient height for placing under overflow spout. In use, the Catch Bucket is placed under the mouth of the spout and the Overflow Can filled until water begins to flow. When flow has ceased, the water in the Catch Bucket is discarded and the Bucket is replaced. If, now, an object is placed in the Overflow Can, there is an outflow from the Can into the Catch Bucket which exactly equals the volume of the body.

Overflow Can and Catch Bucket 85

31–20 OVERFLOW CAN 50

31–21 CATCH BUCKET 35

31–23 LOADED WATERPROOF WOODEN CYLINDER, adapted for use in Displacement and Density experiments.
This is a cylinder loaded to just sink in water, with a water-proof paraffine finish. It is especially adapted, from its size (3¼ inches by 1⅝ inches diameter), for use with Overflow Can No. **31–20** . . .27

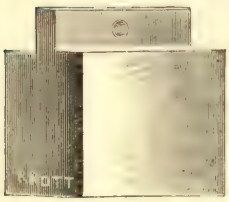
31–25 WATERPROOF CHERRY BLOCK, useful as specimen for measurement as well as for experimentation and density work.
This block is made of cherry with sandpaper finish and paraffined to make water-proof. Its size is 3 × 3 × 1½ inches thick, which makes it especially adapted for individual student work 16

31–27 LOADED WATERPROOF RECTANGULAR BLOCK for Displacement and Density experiments.
This is a block, 1¾ inches square by 2¾ inches high, loaded to just sink in water and made water-proof by boiling in paraffine 22

31–35 LEAD SINKER for determining the Specific Gravity of Lead, and for use as Sinker in determining the Specific Gravity of an object lighter than water.
This sinker is of uniform density and of convenient mass and size for use in Density experiments. It is provided with small brass hook for suspension 13

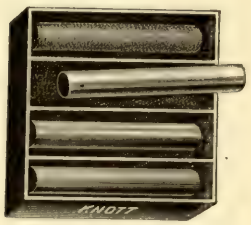
31–40 SULPHUR SPECIMEN for the determination of the Specific Gravity of Sulphur.
This is a specimen about 3 inches long by 1½ inches in diameter 06

31–45 SPECIFIC GRAVITY DETERMINATION GROUP, consisting of Nos. **31–18** to **31–40** 1.65



No. 31–55

No. 31–60



No. 31–67

31–55 ALUMINUM BLOCK, of commensurable volume for use in determination of the specific gravity of aluminum, of a liquid by buoyancy method, of a solid lighter than water by the sinker method. This is a cubical block of cast metal, 1½ inches on an edge, with a cast ring for attachment in the upper surface. See Turner and Hersey Laboratory Sheets **$0.45**

31–60 ALUMINUM CYLINDER, after Millikan & Gale's "A Laboratory Course in Physics," Experiment 7, for testing Archimedes' Principle for Immersed Bodies . . . . . **.40**

31–65 PARAFFINE CUBE, for density experiments. This is a cast cube of paraffine, measuring 5 centimeters on an edge and weighing approximately 100 grams . . . . . **.27**

31–67 SPECIFIC GRAVITY SPECIMENS, for mensuration and specific gravity work. These specimens are rods of ½ inch diameter, 2 inches long, accurately machined. The set consists of aluminum, brass, steel, and hard rubber, enclosed in small carboard box . . . . . **.95**

31–67a ALUMINUM ROD, ½ × 2 inches . . . . . **.24**

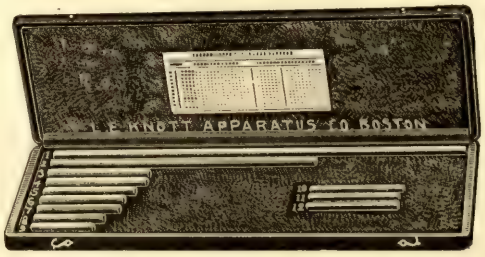
31–67b BRASS ROD, ½ × 2 inches . . . . . **.20**

31–67c STEEL ROD, ½ × 2 inches . . . . . **.18**

31–67d HARD RUBBER ROD, ½ × 2 inches . . . . . **.35**

31–70 SPECIFIC GRAVITY SPECIMENS, consisting of twenty different substances of irregular shape, but of convenient size for individual student work in density. Set complete in neat cardboard box . . . . . **.95**

No. 31–80



No. 31–85

31–80 SPECIFIC GRAVITY SPECIMENS, for exact determinations of volume by direct measurement; also for determination of density by measurement of mass, illustrating by direct comparison the relations between volume, mass and density. These specimens consist of twelve cubes, accurately machined to exactly one centimeter on an edge, thus giving a volume of one cubic centimeter. The mass, therefore, of each cube will be the density. The set consists of the following specimens, — one each of magnesium, aluminum, zinc, tin, iron, nickel, copper, silver, lead, and alloys of copper and zinc, copper and aluminum, and copper and tin. Each set is enclosed with index in a velvet lined case . . . . . Duty Free **$9.85**

31–85 SPECIFIC GRAVITY SPECIMENS, for showing that lengths are inversely proportional to specific gravity when comparing substances of same diameter and mass; also, for exact determinations of volume by direct measurements. These specimens consist of twelve cylinders, machined to exactly 5 millimeters in diameter and length adjusted to weigh exactly 10 grams. The set consists of same metals as listed under No. **31–80,** enclosed in velvet-lined hinged case, with index on under side of cover . . . . . Duty Free **10.85**

No. 31–105

31–97 **WATERPROOF WOODEN ROD** for determination of the specific gravity by the flotation method.
This is a rod of wood of uniform density, 20 centimeters long, 1 centimeter in diameter, coated with paraffine to make waterproof **$0.06**

31–100 **BRASS SUPPORT** for holding No. **31–97** in vertical position.
This is a spring brass support, designed to clamp securely on the side of a battery jar and to hold No. **31–97** in an erect position by means of two aligned round sockets . . . . . **.15**

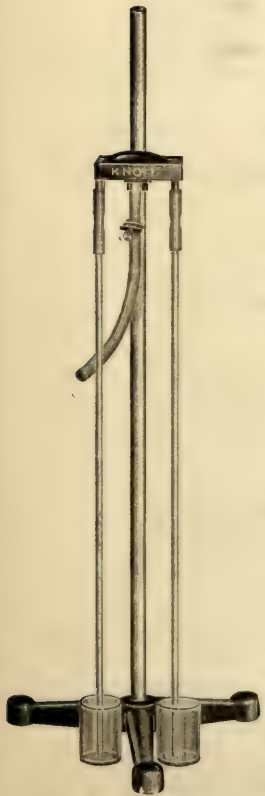
31–105 **DENSITY BY FLOTATION APPARATUS** consisting of Nos. **31–97** and **31–100** with No. **31–265b** Glass Jar, complete . . . . . **.46**

No. 31–125

No. 31–131

No. 31–135

No. 31–140



No. 31–145

31–125 **SPECIFIC GRAVITY BOTTLE WITH THERMOMETER STOPPER** for determination of the specific gravity of a liquid by the weight of a measured quantity; capacity 50 cubic centimeters **$2.60**

31–130 **SPECIFIC GRAVITY BOTTLE WITH CAPILLARY STOPPER** for determination of the specific gravity of a liquid by the weight of the measured quantity. Capacity 25 cubic centimeters, accurately adjusted . . . . . **.70**

31–131 ——, same as above, capacity 50 cubic centimeters **1.00**

31–132 ——, same as No. **31–130,** but unadjusted . . . . . **.33**

31–135 **SPECIFIC GRAVITY BOTTLE** for determination of the specific gravity of a liquid by the weight of the measured quantity.
This is a small, glass-stoppered bottle of convenient size for experimental work. It is quite frequently desired by instructors in preference to the especially adapted types . . . . . **.10**

31–140 **SPECIFIC GRAVITY BOTTLE WITH CAPILLARY STOPPER,** double-walled and evacuated. Capacity 25 cubic centimeters **3.15**

31–145 **HARE'S BALANCING COLUMNS APPARATUS** for determining the specific gravity of a liquid by means of balancing columns.
This apparatus consists of a support at the top of which is mounted a special lead tube with three branches. To the two outside branches are attached two lengths of glass tubing; to the central, the tubing through which the air is to be exhausted from both tubes.
Complete as illustrated with two jars, rubber tubing connections and pinch-cock, but without upright support . . . . . **.85**

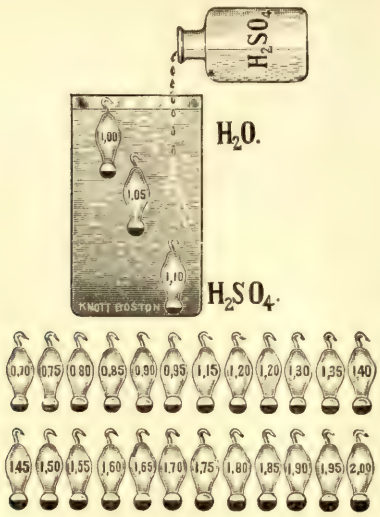
31–145a **SPECIAL LEAD PIECE WITH THREE BRANCHES** . . . . . **.22**

31–145b **GLASS TUBES** . . . . . Per Pair **.20**

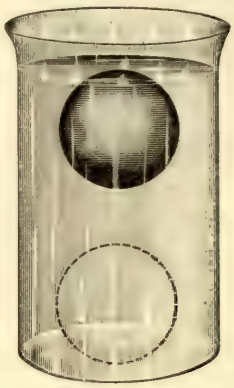
31–145c **PINCHCOCK** . . . . . **.16**

31–145d **GLASS JARS** . . . . . Per Pair **.20**

31–145e **UPRIGHT SUPPORT AND CLAMP** **1.25**



No. 31–150



No. 31–160

No. 31–170

31–150 SPECIFIC GRAVITY PLUMMETS, for Lecture Table use.
This apparatus consists of twenty-seven plummets indicating by sinking or floating, Specific Gravities ranging from .7000 to 2.000 by steps of .0500.
On the demonstration desk, if placed in a liquid in a tall jar, and other liquids which do not mix are carefully placed in this jar, a spectacular result follows. It is highly recommended, also, for showing the varying density by pouring sulphuric acid into water.
Duty Free **$9.85**

31–160 DENSITY INDICATING BALL, for illustrating the changes in the density of a liquid induced by variations in temperature.
This is a metal ball, 40 millimeters in diameter, nicely adjusted to float in cold water, but which will sink in warm water **3.85**

No. 31–225

No. 31–227

31–170 HYDROMETER (CONSTANT WEIGHT), for finding Specific Gravity of light liquids, Beaumé's Scale 70-10, Specific Gravity Scale 0.7000 to 1.000 . . . . . **$0.60**

31–171 HYDROMETER (CONSTANT WEIGHT), for heavy liquids, Beaumé's Scale, 0–70, Specific Gravity Scale 1.000 to 2.000 . . . **.60**

31–175 HYDROMETER (CONSTANT WEIGHT), for both light and heavy liquids **1.25**

31–185 NORMAL HYDROMETERS, accurate to the second and third place of decimals, especially adapted for laboratory research where the specific gravity of small quantities of liquid are under experimentation.
Set consists of six spindles with specific gravity scale of range from 0.7000 to 2.000, with thermometer and cylinder in neat case . . . . . Duty Free **7.35**

31–187 ——, same as above, but with thermometer in each spindle. Set of six with range as above, with cylinder in case . . . . . Duty Free **9.15**

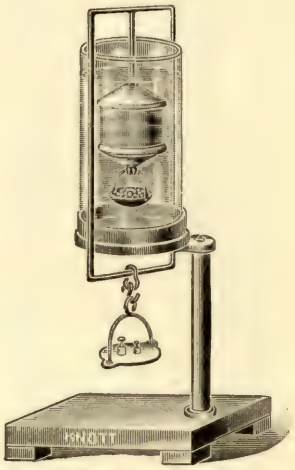
31–225 CONSTANT VOLUME HYDROMETER TUBE, after Millikan & Gale's "A Laboratory Course in Physics."
This is a tube of special design, shape as illustrated . . . . . **.33**

31–227 CONSTANT WEIGHT HYDROMETER TUBE, after Millikan & Gale's "A Laboratory Course in Physics," for determining the Density of a Liquid by the flotation method.
This is a thin-walled cylindrical glass tube, about 24 inches long, one end closed . . . . . **.40**

No. 31–232

No. 31–240

No. 31–242



No. 31–245

31–230 DEMONSTRATION HYDROMETER, illustrating the principle of the hydrometer and the method of determining the specific gravity of liquids by buoyancy.
This is a rod, 30 centimeters in length, 1 square centimeter cross section, graduated the entire length to millimeters. It is paraffined in order to make waterproof.
Demonstration Hydrometer, without Jar **$0.25**

31–232 DEMONSTRATION HYDROMETER, with Jar . . . . . **.65**

31–240 NICHOLSON'S HYDROMETER, for determining the Density of a Body Heavier than Water.
This is a Constant Volume Hydrometer constructed of metal. It consists of a hollow cylinder attached to the lower end of which is a basket heavy enough to keep the cylinder upright; at the upper end is a vertical rod carrying a pan for holding weights.
In use, sufficient weight is put in the pan to sink the Hydrometer to a fixed mark on the vertical rod. The body whose specific gravity is to be determined is then placed in the basket and enough weights added to sink the apparatus again to the fixed point. (The weight of the body must be less than the weight used to sink the hydrometer at first.) The difference in weight will give the weight of the body. This body is now placed in the basket and weights are added to sink the hydrometer again to the fixed mark. The difference above obtained divided by this weight will give the density of the body. Without jar **1.85**

31–242 ——, same as above, but made entirely of glass. Recommended for lecture use. Without jar . . **2.50**

31–245 TRALLES HYDROMETER, for same purpose as above, but distinguished by the great load it will carry. The added weights also favor stable floating . . . . . Duty Free **$9.65**

31–250 HYDROMETER JARS, for use where a tall jar of small diameter is desired.

These jars are of clear, white glass, with foot and rim.

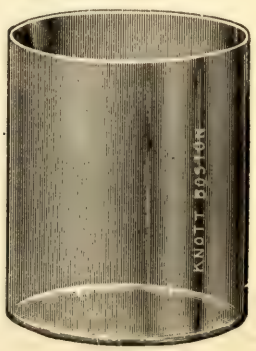
	a	b	c	d	e
Size, inches	12 × 1½	12 × 2	15 × 2	15 × 3	18 × 3
Price	**$0.40**	**.45**	**.75**	**.95**	**1.25**

31–265 GLASS JARS, of excellent quality.

	a	b	c	d
Size, inches	2¼ × 3¼	4 × 5	6 × 8	8 × 12
Price	**$0.12**	**.25**	**.40**	**1.50**

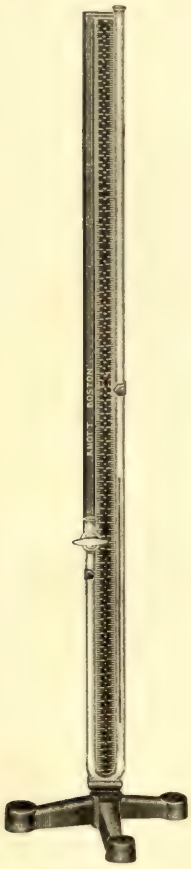
RECTANGULAR BATTERY JARS. See Index.

No. 31–250

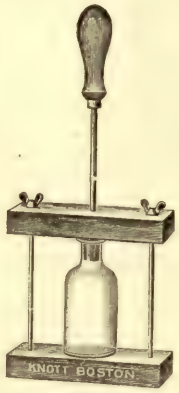


No. 31–265

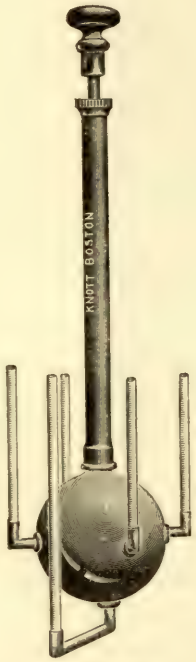
PRESSURE OF LIQUIDS



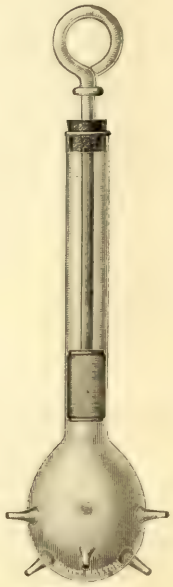
No. 20–251



No. 20–260



No. 32–30



No. 32–35

20–251 INCOMPRESSIBILITY OF LIQUIDS APPARATUS, IMPROVED DESIGN, for the quantitative observation of the incompressibility of liquids.

This apparatus consists of a tube with indicating capillary. The liquid to be observed should fill the short arm of the tube and should rise in the long arm to near the top of the capillary. If mercury is poured into the long arm, the liquid, if compressible, will indicate the amount, if any, in the capillary.

This tube may be mounted on our No. **41–116** Boyle's Law Stand. Tube only **$2.50**

20–260 INCOMPRESSIBILITY OF LIQUIDS APPARATUS, for showing elasticity and incompressibility of liquids.

This apparatus consists of a support which answers the double purpose of supporting a plunger and a bottle as well as that of a clamp.

In use, the bottle is filled with the liquid, a one-hole rubber stopper placed in the neck, the end of the plunger placed in the hole and the bottle clamped firmly in place by means of thumb nuts. If the plunger is now thrust into the bottle, the liquid, being incompressible, the bottle will burst.

Complete with three bottles **1.25**

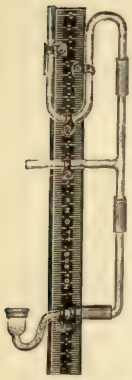
32–30 UNIFORM PRESSURE SYRINGE OF BRASS, for demonstrating that the pressure of liquids is equal in all directions against the sides of the containing vessel.

This apparatus consists of a metal sphere to which is attached a brass tube with piston. On the surface of this sphere are " bosses " into which glass tubes are sealed in a vertical position. If the apparatus is filled with water, or any other liquid inactive on the metal, any pressure exerted by the piston will be transmitted in all directions against the inner sides of the sphere. As this pressure is equal in all directions, the water will rise from the glass tubes a uniform distance.

This is a convenient form for the demonstration of the principle involved, and the accuracy of the result and the cleanliness of operation make it a valuable addition to a laboratory equipment . **11.00**

32–35 UNIFORM PRESSURE SYRINGE, for demonstrating that the pressure of liquids is equal in all directions against the sides of the containing vessel.

This is an apparatus similar in design to the above, but made of glass, without the pressure indicating tubes. The equality of pressure is illustrated by the spouting liquid **1.90**



No. 32–50

32–50 PRESSURE GAUGE, with Equalizing Tube after Cheston, Dean and Timmerman's "Laboratory Manual of Physics," Experiment 4, for measuring directly the pressure of liquids at various depths.

This apparatus consists of a Pressure Diaphragm in direct connection with a Manometer, the whole mounted on a wooden scale. This form is an improvement over the old types, in that the level of the liquid in the Manometer may instantly be made the same in both branches by allowing an equality of pressure by opening the horizontal tube noted in the illustration at about the central point **$1.80**

Nos. 32–60 and 32–62

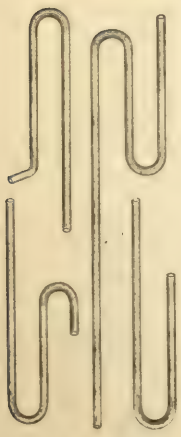
32–60 PRESSURE GAUGE, HALL'S IMPROVED, for demonstrating that pressure upon a surface varies with the depth but not with the angle of inclination.

This apparatus has been greatly improved to obviate the deteriorating quality of the rubber belt as used in former designs, the universal movement of the pressure chamber being imparted by a chain and sprocket operated by a small crank. Illustration pictures our No. **32–62** Pressure Gauge Attachment valuable when it is desired to project the indicating globule on a screen. Pressure Gauge only, without Jar or Attachment **2.50**

32–62 PRESSURE GAUGE PROJECTION HOLDER, as designed by Dr. Hall, for use in the lantern slide carrier in projecting the indicating globule in Manometer Tube of above.

This Holder is designed to fit the Standard Lantern Slide Carrier. The Manometer Tube, as illustrated above, is clamped by two discs eccentrically mounted. The globule shows through the center of the opening. Holder, only **$0.65**

32–65 PRESSURE GAUGE, simple form, consisting of a pressure chamber in connection with an index tube . . . . . **.30**



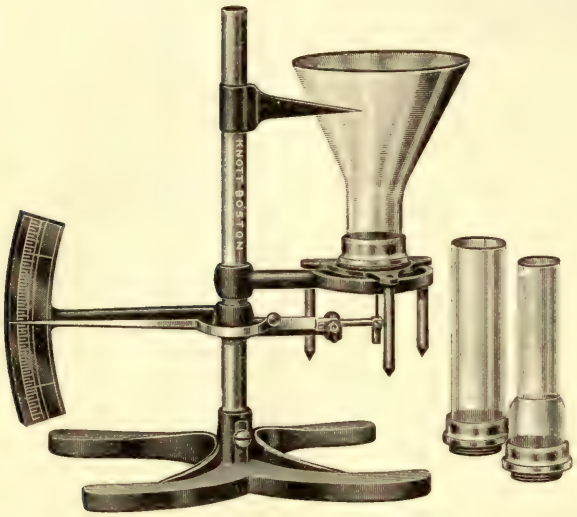
No. 32–75

32–75 PRESSURE TUBES, after Gage's "Introduction to Physical Science," for showing that at same depth pressure is equal in all directions.

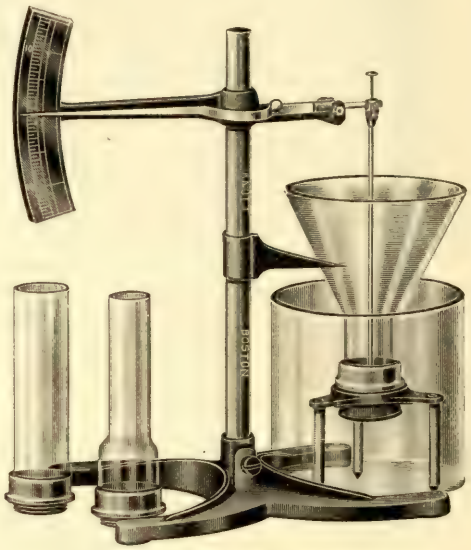
The set consists of four tubes, U form, the shorter arms of which open in different directions, — upward, downward and sideways.

In use, an equal amount of mercury is placed in the bends and the tubes thrust into a jar filled with the liquid until the openings of the short arms are all brought at the same depth. The pressure indicated by the mercury, registers the same.

Per set of four tubes **1.15**



No. 32–100 (Fig. 1)



No. 32–100 (Fig. 2)

32–100 NICHOLS' PASCAL'S VASES for quantitative determination of the laws governing liquid pressure, both upward and downward; also, that pressure upon a surface is independent of the shape of the containing vessel.

The apparatus consists of a standard to which are attached the various supporting arms of which three are used in the experiment. (See Fig. **1** above).

DOWNWARD PRESSURE. This apparatus shows the method of assembling when it is desired to measure the downward pressure, its relation to the size of the surface acted upon, the effect of the amount of liquid in the vessel above the surface and the perpendicular height of the liquid.

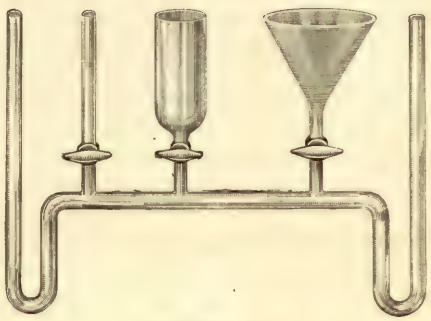
If water is then poured into the vessel, the upward pressure will be indicated by the long arm of the lever moving upward. The amount of pressure may be calculated from the factors obtained by the measurements of the two arms of the lever.

UPWARD PRESSURE. Fig. **2** illustrates how the apparatus is assembled for the study of upward pressure of a liquid on a submerged surface, showing that the upward pressure bears the same relation to the depth as does the downward pressure.

The apparatus is substantial and beautifully constructed throughout. Attractive dark finish with nickel-plated fittings. The design is such as to permit of exact determinations with the least inconvenience in manipulation. We call especial attention to its compactness, stability, and its cleanliness in operation.

Complete with all parts **$18.00**

No. 32–110



No. 32–115

32–110 PASCAL'S VASES, WITH BALANCE ARM AND WEIGHT, for demonstrating that pressure is independent of the shape of the containing vessel.

The apparatus consists of a casting for supporting the vessels of different shapes, also for a standard which carries at its top a pivoted lever on the short arm of which may be attached a hanger bearing a brass disc the surface of which is ground to fit a cylindrical part of the casting above mentioned.

In use, the hanger is balanced by placing weights on the long arm of the lever. An index attached to the standard indicates the height of the water in the vessel.

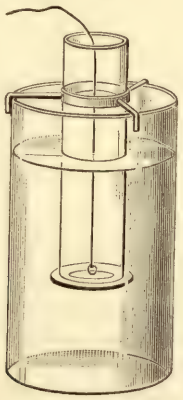
The hanger is attached to the arm of a balance.

Complete, as illustrated with jar and three vessels of different shapes, balance arm and weights . . **$9.45**

32–115 PASCAL'S VASES WITH MERCURY INDICATOR, for demonstrating that pressure is independent of the shape of the containing vessel, depending only on the area pressed upon.

The illustration pictures an instrument made entirely of glass. It consists of three differently shaped vessels, each connected through stop-cocks of equal bore to a common tube terminating at each end in manometer tubes, which, in use, have their bends filled with mercury, which acts as the pressure indicator.

This instrument has become popular from its quality of being self-contained. Besides its extreme sensibility, its convenience in operating and its cleanliness, this instrument is commended for the rapidity with which it can be operated **6.75**



No. 32–120

32–120 BUOYANCY OF LIQUIDS APPARATUS, for illustrating vertical upward pressure.

This apparatus consists of a glass disc the surface of which is ground to fit the lower rim of a glass cylinder. In use, this disc is held in junction to the cylinder by means of a string attached to the center of the disc until a buoyancy pressure sufficient to counteract the weight of the disc is reached. This pressure may be measured by carefully pouring water into the cylinder until the mass equalizes the buoyancy pressure of the liquid on the disc.

Complete as illustrated, with jar, glass cylinder, disc, and support for cylinder **$2.05**

No. 32–130

32–130 LIQUID PRESSURE TUBES, after Chute's "Physical Laboratory Manual," Problem **52,** for verifying the Laws of Liquid Pressure.

These tubes are of glass, 50 centimeters long, of different diameters, graduated into millimeters along their entire length, the zero of the scale being at the closed end.

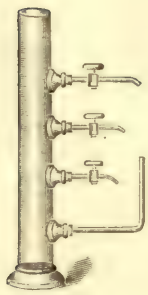
In using these tubes, it is necessary to have a deep cylindrical glass vessel. Under No. **32–132** will be found one especially adapted for this use . . . . . Per Pair **$2.25**

32–132 CYLINDRICAL GLASS VESSEL, for use with above Liquid Pressure Tubes.

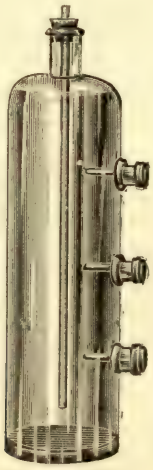
This vessel is of simple construction to obviate the excessive cost of a vessel of sufficient depth that can be purchased commercially **1.65**

32–135 PRESSURE U-TUBES, for experiments in Fluid Pressure, consisting of tubes with arms of equal lengths.

	a	b	c	d	e
Length . . .	10	12.5	15	30	50 centimeters
Price	**$0.14**	**.16**	**.18**	**.30**	**.60**



No. 32–150



No. 32–160

32–150 TORRICELLIAN LAW APPARATUS, for determination of the law s equals $\sqrt{2gh}$, where s equals the speed of efflux, g the value of gravity and h the height of the liquid; also for simple demonstration of variable pressure according to depth below the free surface of the liquid.

This apparatus consists of a tall glass cylinder with lateral openings, three closed by stop-cock tubes, the fourth terminating in a tube with a vertical branch which may be stopped by rubber tubing and pinchcock. If the liquid is allowed to issue vertically it will rise to nearly the height of the free surface of the liquid in the jar. This height would be the same except for the friction at the orifice, the weight of the falling liquid and the resistance of the air. By turning the stop-cocks in the other lateral tubes, allowing the liquid to issue forth, it will be noted that the pressure varies as the depth of the orifice below the free surface, the paths of the issuing stream following a parabolic curve due to the force of gravity. By observation and calculation it may be determined that the focus of these parabolic curves is as much below the orifice as the surface of the liquid is above it and that the curves are flatter the greater the pressure under which they issue.

Complete as illustrated **$7.90**

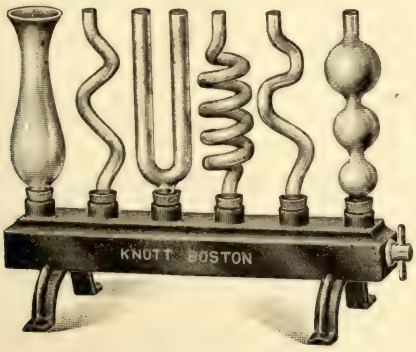
32–160 MARIOTTE'S BOTTLE, after Hall & Bergen's " A Text-Book of Physics," page 44, for the study of Fluid Pressure at varying levels.

Complete, as illustrated, with rubber stoppers and glass fittings **3.75**

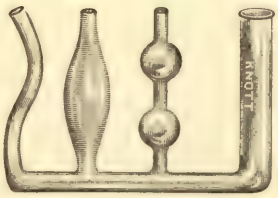
No. 32–165

32–165 EIGHT-IN-ONE APPARATUS, after Gage's "Introduction to Physical Science," Experiment **32**, for the study of the Torricellian Laws, as described under **No. 32–150.**

This apparatus, advised for Lecture Table work, consists of a brass cylinder, 6 feet long, surmounted by a reservoir. At various heights along the tube are attached lateral tubes with screw caps. By the successive openings of these screw caps, the paths of the issuing streams are readily observed. It will be noted that the stream issuing from the lowest orifice shows flattest, thus showing the greatest pressure. The streams issuing from the other orifices all take a curved path, the curvatures, however, depending upon the depths of the orifices below the free surface of the liquid **$11.25**



No. 32–180



No. 32–185

32–180 LIQUID LEVEL APPARATUS, IMPROVED FORM, for illustrating the tendency of a liquid to seek its own level.

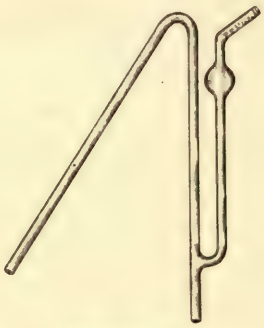
This apparatus consists of a cast-iron reservoir with open tuberatures at the top into which are set glass tubes of various shapes and sizes. A liquid poured into the funnel-shaped tube will fill the iron reservoir and rise in the tubes at equal rates and remain at the same height. The U-shaped tube has branches of equal area.

This apparatus must not be confused with other designs. Our design is of substantial construction, handsome in appearance, obviating the inconveniences of less modern types **$3.30**

32–185 LIQUID LEVEL COMMUNICATING TUBES, for illustrating the tendency of a liquid to seek its own level.

This apparatus, constructed entirely of glass, consists of four tubes of different shapes and sizes communicating with each other by means of a common connection . . . . . **.70**

No. 32–200



No. 32–205

No. 32–215

32–200 SIMPLE SIPHON for the qualitative and quantitative study of the principles involved.
Consists of a glass tube, bent in shape as illustrated. Length of arm, 12 inches **$0.20**

32–205 SIPHON WITH SUCTION TUBE . . . . . **.35**

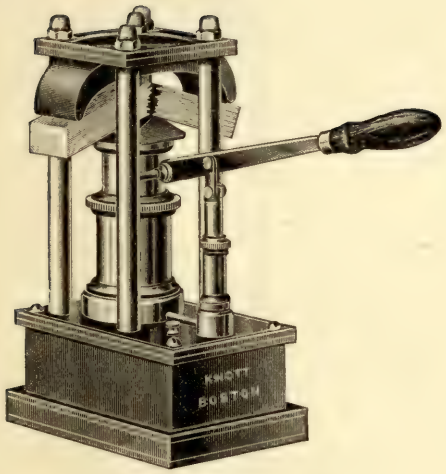
32–215 TANTALUS CUP OR INTERMITTENT FOUNTAIN, illustrating the principle of Intermittent Springs.
This standard design is in reality a Siphon, the long arm of which is held in a stopper in the constriction of the goblet-shaped glass vessel.
In use, water is led into the goblet. This water will rise in the short arm of the siphon until it reaches the bend, when it will flow down through the long arm of the siphon and continue to flow until the level of the water gets below the end of the short arm. This action will be continuous if the inflow is less than the outflow through the siphon . . . . . **.70**

No. 32–230

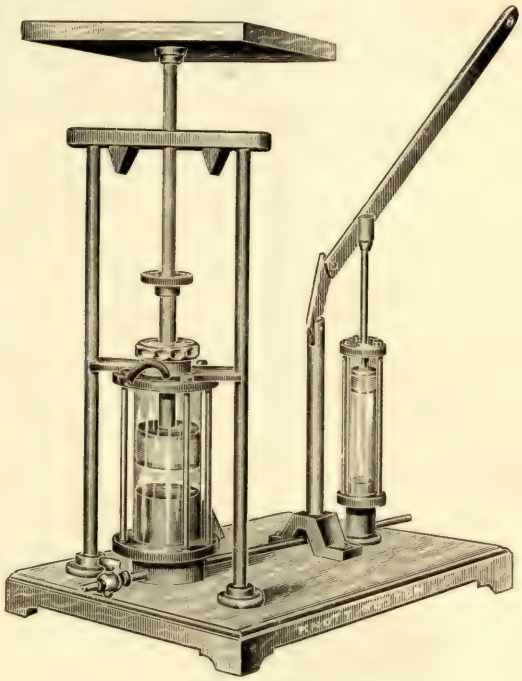
32–230 CARTESIAN DIVER, illustrating the different effects of suspension, immersion, and floating.
This diver is of colored glass, weighted to just float in water. It is hollow inside, but has a small opening at the end of a protuberance horizontal to the perpendicular axis of the figure. In use, the figure is placed in a jar nearly filled with water. The jar is then covered by a rubber diaphragm which must be fixed air-tight. Any pressure on this diaphragm will cause a disturbance throughout the liquid equal in all directions, also causing water to enter the interior of the diver through the opening above mentioned, resulting in the sinking of the diver to a depth depending upon the amount of pressure on the diaphragm The release of this pressure results in the diver expelling the water through the opening, causing the diver to rise and, in rising, to spin owing to the reaction of the liquid through the opening.
The apparatus as illustrated is instructive and amusing, as the little figure is susceptible to the least movement of the diaphragm, causing it to go through some very peculiar antics.
Complete as illustrated . . . . . **.80**

32–231 CARTESIAN DIVER, only . . . . . **.25**

HYDRAULIC PRESSES



No. 34–10



No. 34–15

34–10 HYDRAULIC POWER PRESS, for illustrating the force of a Hydraulic Press.

The instrument illustrated is more than a model, in that it may be subjected to very severe tests for breaking strengths. It is built of cast iron, bronze and steel throughout, all parts being finished as strikingly as possible. The cylinders are accurately turned and fit perfectly, the large one having an internal diameter of 2½ inches, the small cylinder of the force pump being 7/16 of an inch. In working our design, or in working any design of Hydraulic Press we advise the use of oil, inasmuch as this liquid prevents wear of the working parts.

This instrument has been subjected to very severe strains in our laboratory and each instrument shipped is tested to give the calculated efficiency **$28.50**

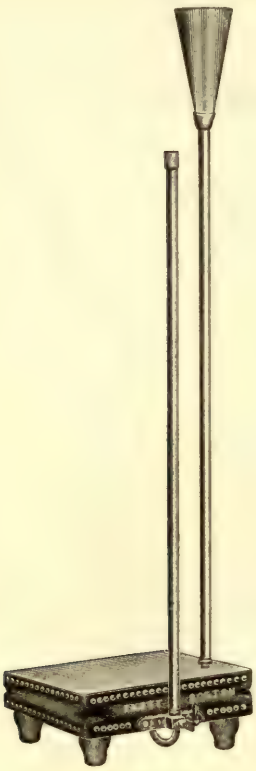
34–15 HYDRAULIC PRESS, WORKING DEMONSTRATION MODEL, for the study of the structure of a simple press demonstrating how Pascal's Law can be applied to secure great force.

This press is a demonstration model of a design calculated to show forth all essential working parts. Thus, the cylinders are of glass that the well-fitting pistons may be seen in operation. Although a demonstrating model, this press may be used to break bars of iron, wood, etc., the large piston being provided with a self-releasing valve which practically makes it impossible to have an accident with the machine, whatever weight is placed upon the table . . . . . Duty Free **29.50**

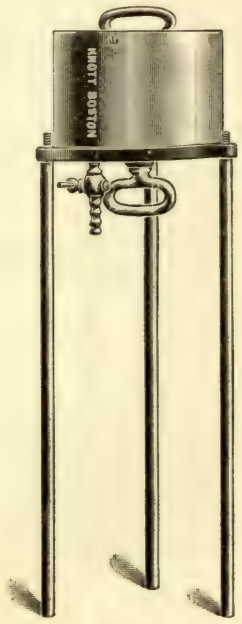
No. 34–20

34–20 HYDRAULIC PRESS, for the study of the principle involved in the Hydraulic Press.

This is the standard simple model of glass, the valves of which are colored so that their operation may readily be observed **1.65**



No. 34–30



No. 34–40

34–30 HYDROSTATIC BELLOWS, for illustrating an application of Pascal's Law.

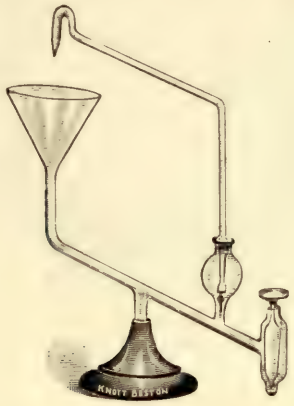
Our design consists of a strongly constructed bellows 30 centimeters square, supported by legs. Attached to this bellows is a brass tube upright, 6 feet long, terminating at its top in a conical reservoir. This upright is separable into two parts as illustrated. All parts are handsomely finished and designed to withstand reasonable strain, the pneumatic bellows being sufficiently strong to hold a person **$22.50**

34–40 SEVEN-IN-ONE APPARATUS OR SPIROMETER, GAGE'S IMPROVED, for demonstrating fundamental principles in Pneumatics and Hydraulics.

This apparatus consists of a seamless brass cylinder, 6 inches in diameter, mounted on a metal casting, provided with " bosses," into which rods may be screwed from either side. The cylinder is provided with an ingeniously designed piston which, owing to its construction, has greater efficiency, the longer the use. This construction also obviates the sticking of the washers and leakage around them. Each instrument is provided with our detachable handle in the piston head, a fixed handle with brass stopcock, and nipple. This apparatus, as implied from the name " Seven-in-One," will illustrate the principles involved in seven different instruments, as follows. — Hydraulic Lift, Hydraulic Press, Incompressibility of Liquids Apparatus, Pascal's Law Apparatus, Pneumatic Lift, Hydrostatic Bellows, Magdeburg Hemispheres.

It is handsomely finished in lacquer and nickel plate and is furnished complete with rods for supports. **8.15**

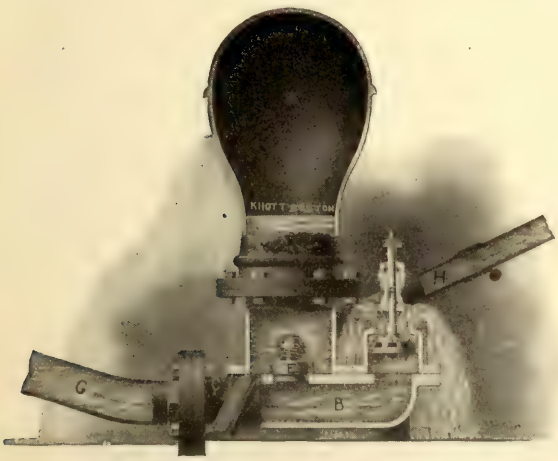
RAMS PUMPS



No. 35–10

35–10 HYDRAULIC RAM, illustrating the increase of pressure due to interrupted flow in a stream of water. This model is made entirely of glass, with black glass valve. It is mounted on a wooden base; its size, 17 × 13 inches, is ample for lecture hall demonstration.

In operation, water is poured into the conical reservoir whence it flows down and is automatically cut off, the interrupted flow causing an increased pressure which forces the water through a valve back through the delivery tube into the conical reservoir **$3.30**



No. 35–15 (Sectional View)

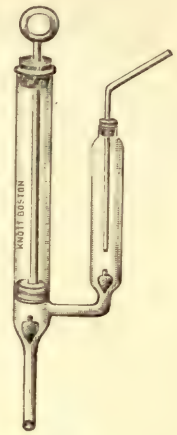
No. 35–15

35–15 HYDRAULIC RAM, commercial form, capacity 60 to 100 gallons per hour to a height of 60 feet.

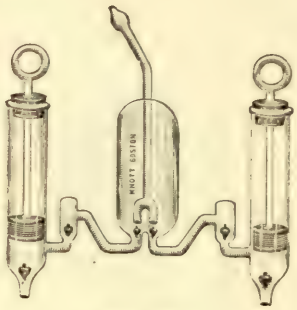
This instrument follows very closely the construction of No. **35–10** model. By referring to the sectional view it will be noticed that it consists of an Air Chamber A, the Body B, and the Snifting Valve for air inlet C. The Check or Inlet Valve E is located between the supply pipe and the air chamber. The Impetus Valve F is located at the end of the supply pipe.

The water flowing through Supply Pipe G passes through the outlet in the impetus valve until the increasing velocity creates sufficient pressure to close the valve checking the flow of water in this direction, and to force open the Check Valve E. The water having passed into the air chamber, is then forced through the Delivery Pipe H by the increased pressure on the air chamber. After forcing the water into the air chamber, the pressure is relieved and the impetus valve opens, only to go through the operation again and again, continually delivering water. A supply of from 2 to 3 gallons per minute is required to operate this valve successfully. Size of drive pipe, ¾ inch; discharge pipe, ½ inch diameter; total approximate weight 27 pounds **$11.00**

No. 35–30



No. 35–32

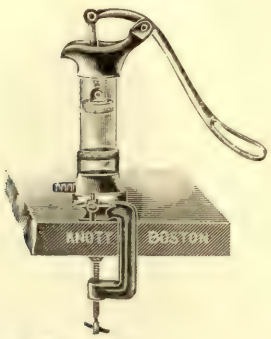


No. 35–40

35–30 MODEL OF LIFT PUMP, entirely of glass with colored glass valve with ground seat. Total length 15 inches **$1.60**

35–32 MODEL OF FORCE PUMP, made entirely of glass, with black glass valves, with ground seats . . . **1.95**

35–40 FIRE ENGINE PUMP, illustrating the practical application of the simple force pump.
This pump is in reality a double force pump with a central reservoir having a discharge tube. Its practical application will be found in the walking beam fire engine pump.
This model is entirely of glass, the valves being constructed of black glass with ground glass seats . . **2.90**



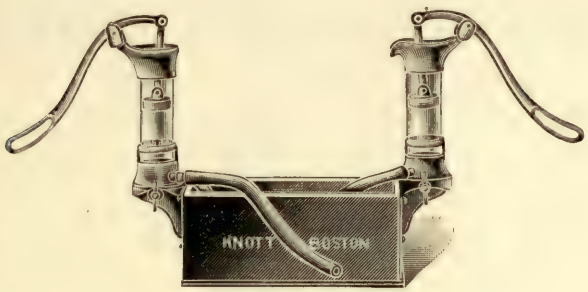
No. 35–50

No. 35–52

35–50 T–BEAM WATER LIFT PUMP, for use with our No. **5–1000** Universal T–Beam Basic Clamp " A."
In this design, highly efficient and exceedingly scientific in appearance, we present a pump capable of use in many positions, — one that is patterned after commercial forms, constructed so that all working parts are in full view. Cylinder 1½ inch diameter, capable of lifting a large amount of water.
Without Clamp **$6.85**

35–52 T–BEAM WATER FORCE PUMP, for use with our No. **5–1000** Universal T-Beam Basic Clamp " A."
This pump has the same commendable features as the above.
Without Clamp **6.85**

NOTE. These Pumps may be used the same as the old form of metal-fitted glass cylinder pumps in case the T-Beam Clamp is not provided. When so used, the attachment serves as a broad, flat base for supporting. The T-Beam Clamps for holding the pumps rigidly to the table will, however, prevent accidental breakage and will be found a wise investment.



No. 35–55

35–55 T-BEAM LIFT AND FORCE PUMPS with TANK. Either or both of the previous models may be utilized on this tank. The above illustration pictures both, and for the convenience of the buyer we list them under this number. The tank is a special metal casting with side brackets, patterned with the double-beveled lathe-rest slides for the interlocking bases of the pumps. The slides are exactly the same as those on our Basic Clamp " A," as may be noted from the illustrations of our Basic Clamp in Section 5, and the pump attachments are interlocked in exactly the same manner as all attachments for the Basic Clamp. We desire to call attention to the appearance of our design, its construction and the utility of the different parts. It must not be confused with types on the market. The structure of the outfit above illustrated is exceedingly strong, all metal parts being cast from special patterns. The glass cylinders are of a special quality of toughened glass, and the valves are so designed that in operation their use may be readily seen by the pupils.

T-Beam Lift and Force Pumps, complete with Tank, as above illustrated **$19.45**

35–57 T-BEAM BASIC TANK. This tank is the same as above described. It is a special casting with side brackets each with double-beveled lathe-rest slides for the interlocking bases of the pumps. It has a durable black finish and presents a pleasing appearance in the laboratory.

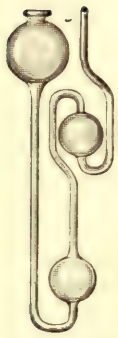
Its use as a general water tank for many experiments should not be overlooked **5.75**

No. 35–75

35–75 MODELS OF VALVES. The pedagogic value of working demonstration models of pumps has been amply verified in the glass models previously listed. The valves, however, are the simplest that can be used. The action of pumps and valves therein has been studied heretofore by means of sectional diagrams. There has been a growing demand for large demonstration models. In the models above illustrated, we demonstrate the most important valve types, as follows, — **butterfly valve, bellows valve, round spring valve, conical valve** and **oil silk valve.** These models are ample in size for lecture work and follow closely the commercial types. Each 6 inches in diameter, carefully made and neatly finished.

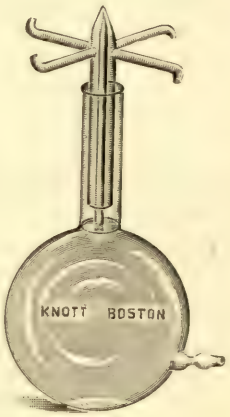
Per set of five as above **$4.50**

REACTION OF LIQUIDS



No. 36–12

No. 36–30



No. 36–50

36–12 HERO'S FOUNTAIN, illustrating the raising of water by the elastic force of air. Made entirely of glass, in form as illustrated.

In operation, the upper bulb is first filled with water, the lower with air. The fountain is started by pouring a small quantity of water into the reservoir. As this flows down, it exerts a pressure on the air contained in the lower bulb. This pressure is transferred to the water in the upper bulb and forces it out through the fountain nozzle **$2.70**

36–30 REACTION APPARATUS, illustrating the reactive force of a laterally escaping stream of liquid.

The apparatus consists of a glass reservoir with fused-on glass indicator at the bottom and a small opening through which the liquid may flow at the side. If the reservoir is suspended and filled with water, the reactive force of the issuing liquid through the opening above mentioned will cause a movement opposite to that in which the water is flowing.

Complete as illustrated, with stationary indicating point **1.00**

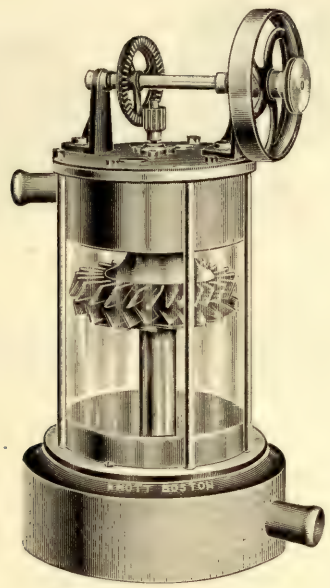
36–50 REACTION GAS AND FLAME WHEEL, for determining the reaction set up by gas escaping from a lateral opening. The apparatus is designed for use either with compressed air, air expanded by heat, or illuminating gas at ordinary pressure, the illuminating gas being ignited or not, as desired.

The slightest flow of a gaseous body, from whatever cause, passing through the four horizontal arms will cause a reaction on the same principle as in Barker's Mill. If the illuminating gas issuing from these four orifices be ignited, the effect is spectacular in the extreme.

CAUTION. Before lighting, the illuminating gas should be allowed to run through the apparatus for a sufficient time to expel all traces of air. Test the gas by collecting in a test tube, the same as in the ordinary hydrogen experiments.

Price complete, as above illustrated **2.50**

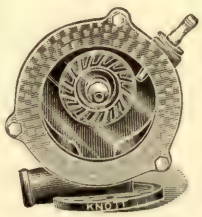
WATER TURBINES WATER WHEELS



No. 37–16

37–16 DEMONSTRATION MODEL OF A TURBINE. This is an illustrative model for the teaching of the fundamental parts of a Water Turbine. It is substantially constructed of glass and metal, all working parts being in full view. The central shaft transmits motion through miter gears to a horizontal shaft which carries a pulley wheel which may be connected to show power.
This model is handsomely finished and substantially constructed. It is 42 centimeters high, — ample for clear view from all parts of the ordinary lecture room . . . . . Duty Free **$52.75**

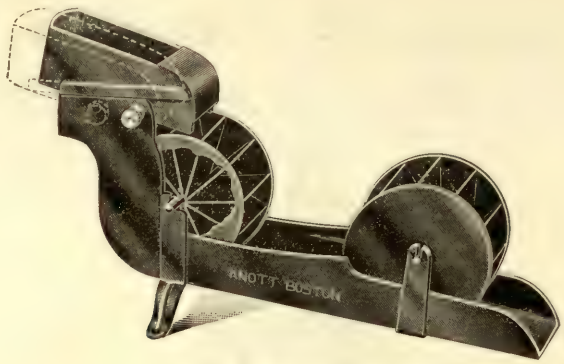
No. 37–20



No. 37–30

37–20 MODEL OF A WATER TURBINE, for connection to a water pump.
This is of simple construction of glass and brass illustrative of same principles involved in more expensive models . . . . . Duty Free **$4.50**

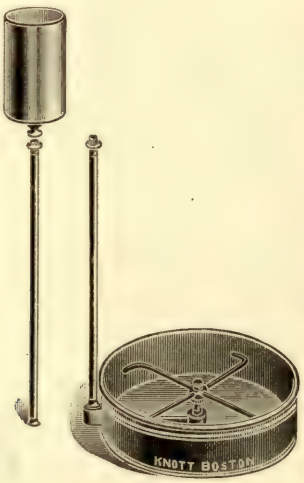
37–30 MODEL OF WATER TURBINE. This model from its design is especially adapted to lecture work. It is sufficiently large for class demonstration and yet will develop power for demonstrating the commerical value of a Turbine. On the demonstration side it has the feature of a glass front which allows full inspection of all working parts. The model is carefully constructed and handsomely finished, the parts within painted a distinguishable color. It is mounted on a firm supporting base.
Duty Free **13.50**



No. 37–50

37–50 CAST METAL WATER WHEEL MODEL, for study and demonstration of the overshot, undershot, and breast water wheels. In our design, which must not be confused with types on the market, we furnish not only an accurately constructed instrument but one that is durable and handsome in appearance. Our runway is cast of metal and neatly finished. The reservoir, also of cast metal is peculiar in design in that, by the use of one water wheel, we can by changing its position demonstrate either the overshot or undershot wheels. As illustrated, the model is set up for an overshot wheel. If desired to demonstrate an undershot wheel the water reservoir must be moved back to position indicated by dotted line and the water wheel reversed.

As may be noted from our illustration this model is distinctive in design, scientifically constructed, and we have no hesitancy in claiming for it a place in a catalog of scientific instruments. Its substantial structure, symmetry of lines, and handsome appearance will recommend it to all **$6.00**



No. 37–60

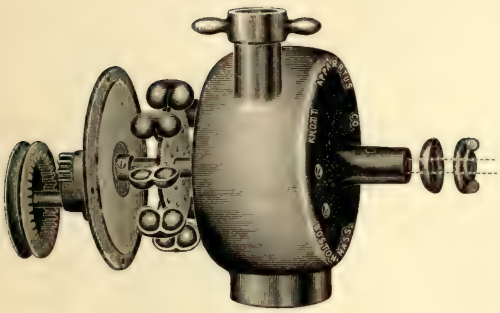
37–60 EXTENSION HEAD BARKER'S MILL, for demonstrating the horizontal pressure of a liquid on the containing vessel.

The design above illustrated has features which obviate all annoyances of the existing types, facilitate the proper cleanly conduct of the experiment, and presents a handsome and scientific appearance.

We have improved our design by making an extension head, — that is, by means of lengths of tubing we can increase or decrease the pressure of the water. This delivery tube has at its top a water reservoir which, in use, should be connected to the faucet by means of a rubber tubing. The revolving turret of our design, differing from existing models, is entirely independent of the source of water supply in that it alone rotates. The bearing, therefore, of the turret, relieved of the weight of water, permits of the use of this design in demonstrating, also, reaction of gases. This reaction is caused by removing the cylindrical reservoir and blowing or pumping air through the tube.

This apparatus stands about 3½ feet high, is handsomely finished throughout and ranks well with other scientific instruments . . . . . Duty Free **$5.75**

WATER MOTORS



No. 38–20

No. 38–25

38–20 THE IMPROVED WALTHAM COUNTERSHAFT GEARED WATER MOTOR. A ⅙ H. P. Motor, of more expensive design than the ones listed below, but one which we strongly recommend for the reason that it illustrates most effectively not only the simple water motor, but also the water motor of greatest efficiency, the speed of greatest efficiency, the relation of speed to water flow, the advantages of the direct drive and gear drive, and the application of the prony break to power generators.

The success of this motor depends upon the following features:

FIRST. The employment of the well-known reacting bucket-wheel which has been proven by a series of scientific tests to give the highest efficiency in a wide range of work.

SECOND. The reducing gear which enables the wheel to give very much more power, the wheel itself running at its normal speed for greatest efficiency.

THIRD. A gear which is easily thrown in and out of mesh so that it may be used or not, as desired.

The motor which we here offer is the first satisfactory attempt at providing a water motor which will give efficient results under a wide variety of conditions. The uses for such a motor in the science laboratory are numerous, taking the place of the whirling table, supplying small power for the small size electric generators, the operating of stirring devices, and the study of the efficiency test by means of the prony break.

This motor is particularly well adapted to the break-test work in view of the geared driver, enabling two separate and complete series of tests to be made on the same instrument, thus offering a valuable series of efficiency tests on both motor and gears **$9.80**

38–25 THE HARCOURT ⅛ H. P. DIRECT DRIVE WATER MOTOR, a substantial, attractive, well-built motor of careful design and giving unusual power for its size. Less substantially built motors are sold in the hardware trade, but should not be confused with the class of motor which we here offer. Motor complete with 4-inch beveled-face emery wheel, cloth buffing wheel, cake of polish and the grooved wooden pulley. Motor and parts securely packed for shipment in a wooden box . . . **5.00**

38–26 HARCOURT ¼ H. P. DIRECT DRIVE WATER MOTOR, same as above described without accessories but larger **8.00**

38–27 STUD SHAFT to slip over the motor shaft of above motor. This shaft has the same threaded end as the ⅛ H. P. motor shaft and all the accessories for this motor can be used on the ¼ H. P. motor simply by the addition of the stud shaft **1.25**

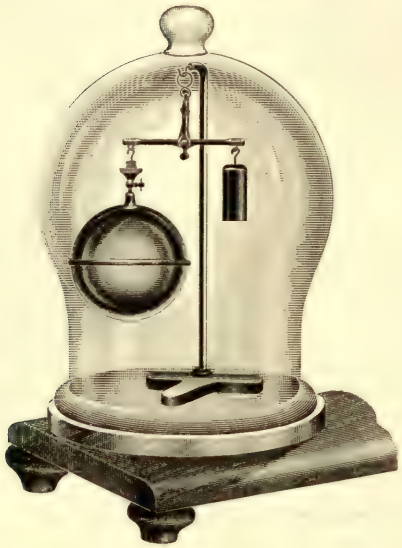
38–29 WATER MOTOR ACCESSORIES, as supplied with our ⅛ H. P. Motor, No. **38–25.** These accessories may be attached to our ¼ H. P. Motor No. **38–26** by means of above stud shaft. These accessories are as follows:

1 Cloth Buffing Wheel
1 Beveled-face 4-inch Emery Wheel
1 Cake Brass Polish
1 Grooved Wooden Pulley

Per Set **2.00**

PNEUMATICS

ELEMENTARY PROPERTIES OF MATTER



No. 40–10

No. 40–22

40–10 **BAROSCOPE GLOBE AND BALANCE,** for demonstrating that air has weight. This apparatus consists of a carefully constructed sensitive balance, to one arm of which is attached a hollow brass globe, 4¼ inches in diameter; to the other a counterpoise weight, exactly balancing the globe when filled with air. This brass globe is fitted with stop-cock with male screw, provided with hook for attachment to beam of the balance.

In use, the globe is exhausted by means of some efficient air pump. It is then attached to the beam of the balance, when it will be readily noted that the air which was within the globe had weight, inasmuch as the balance is destroyed.

Balance complete with brass globe and counterpoise **$6.65**

40–15 ——, same as above, except that a glass globe is furnished in place of the brass **6.35**

40–17 **BAROSCOPE BALANCE,** for use with Weight of Air Globe.

This balance is the same as used with Nos. **40–10** and **40–15** except that no counterpoise is furnished **3.75**

40–18 **BAROSCOPE GLOBE AND COUNTERPOISE,** of brass with stop-cock and hook as used in No. **40–10** **2.95**

40–19 ——, of glass with stop-cock and hook as used in No. **40–15** **2.55**

40–22 **THE COMBINED BAROSCOPE GLOBE AND BELL IN VACUO,** a glass globe 4¼ inches in diameter fitted with brass cap and stop-cock with hook. In the interior is a small bell. (See Section **43**) **5.40**

40–25 **BAROSCOPE GLOBE,** entirely of glass with hook and stop-cock **$2.45**

40–35 **TWO-LITER BAROSCOPE BELL GLASS,** for determining the weight of air, also of any gas.

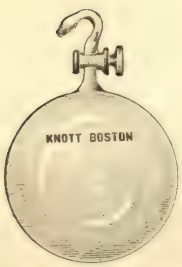
This consists of a globe connected to a bell glass through a stop-cock.

In use the bell glass is placed over the inlet of the pump plate and lower stop-cock opened. All air is then exhausted from the globe. The lower stop-cock is now closed and the gas to be experimented upon is allowed to enter the globe through the upper stop-cock **6.45**

40–50 **BAROSCOPE BOTTLE,** for determining the density of air.

This consists of a bottle of about 2-liter capacity, fitted with a two-hole rubber stopper, glass and rubber tubing connections and four pinchcocks.

The proper conduct of this experiment requires the use of an air pump, a platform scale with weights, and a barometer, as described in our National Physics Course, Experiment M260 . . . . . **1.25**



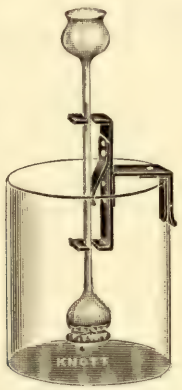
No. 40–25

No. 40–35

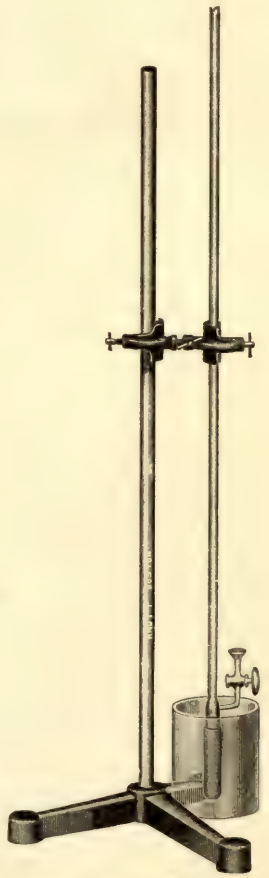
No. 40–90

40–90 OSMOSIS BULB, for showing the diffusion of gases.
This consists of a hollow globular-shaped vessel with neck, constructed of a porous material which permits of rapid diffusion.
About 70 millimeters diameter **$0.70**

No. 20–200



No. 20–215



No. 20–220

20–200 ENDOSMOMETER, for illustrating the phenomena of Endosmose and Osmose.
The apparatus consists of a glass vessel the lower end of which is covered with a membrane, the upper end of which is connected to a glass tube which carries a scale. This vessel is supported so that the membrane is held under solution during examination.
All parts complete as illustrated **$3.70**

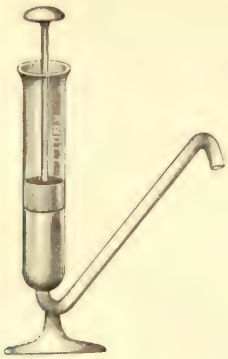
20–215 STUDENTS' OSMOSIS APPARATUS, for qualitative as well as quantitative work in Osmosis.
The apparatus consists of an Osmosis Tube of design as illustrated, held adjustably in a nickel-plated clamp which may be clamped to the side of a jar. One end of the osmosis tube is closed by a thin porous membrane which may be removed and replaced from time to time as needed.
Apparatus complete as illustrated **1.25**

20–220 OSMOTIC PRESSURE TUBE, after specifications by Prof. Thomas B. Freas of the Department of Chemistry in Columbia University, for the rapid illustration of the phenomenon of Osmotic Pressure.
This ingenious device consists of an S. & S. Diffusion Shell attached to a glass chamber which ends above in a heavy wall barometer tube 5 feet long. Entering this chamber is another tube with funnel end and stop-cock through which the solution is allowed to flow.
For rapidity of illustration this apparatus is not excelled and the results obtained are very noticeable within fifteen minutes from the start. Complete with Diffusion Shell **$3.90**

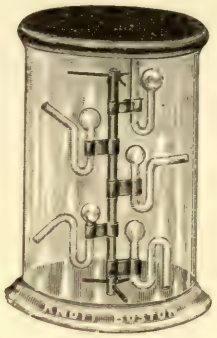
20–222 DIFFUSION SHELL, as used in above apparatus . . . . . Each **.35** Per Lot of 10 **3.00**

Other items above illustrated are:

22–130 UNIVERSAL SUPPORT **2.00**
5–850 UNIVERSAL RIGHT ANGLE CLAMP **1.05**
31–265c GLASS JAR, 6 × 8 inches . . . . . **.40**



No. 41–10



No. 41–20

41–10 MERCURY STORAGE FUNNEL, for storage and delivery of mercury in a cleanly condition.

This design, entirely of glass, mounted on glass foot, consists of a tubular reservoir to the bottom of which is sealed a small bore delivery tube. Mercury is stored in this reservoir, the unclean, lighter and foreign substances rising to float as a scum. The cleanly mercury is delivered from the bottom by the pressure of the piston shown in the illustration.

This instrument, some 8½ inches high, will be found of the greatest service in any laboratory where clean mercury is in constant demand **$2.00**

41–20 GAS PRESSURE APPARATUS, for showing that the pressure upon a gas is transmitted equally in all directions.

The apparatus consists of five small glass manometers held adjustably in small clamps to an upright inside a glass cylinder. This cylinder is sealed air tight at the top by a rubber pressure diaphragm.

In use, the small manometers are filled with some colored indicating fluid. Pressure is then exerted on the gas molecules inside the cylinder by slight pressure on the rubber diaphragm. This pressure is communicated to the open ends of the manometers, each of which, turned in different directions, demonstrates that the pressure transmitted in those directions is equal

Complete as illustrated **5.80**

DIFFUSION OF LIQUIDS

The gradual mixture of two liquids which come in contact

COEFFICIENT OF DIFFUSION INTO WATER

SUBSTANCE	COEFFICIENT		DEGREES CENTIGRADE
Hydrochloric acid	1.74	at	5°
Common Salt	0.76	at	5°
Common Salt	0.91	at	10°
Sugar	0.31	at	9°
Albumen	0.06	at	13°
Caramel	0.05	at	10°

DIFFUSION THROUGH MEMBRANES, — OSMOSIS

If h = height at which flow stops, d = density of sugar solution, and g = gravity,
OSMOTIC PRESSURE = dgh

Percentage of Sugar in Solution	Osmotic Pressure in cm. of Mercury = P.	Density of Solution	Mass of Sugar in 1 c.c. of Solution
1	53.5	1.0039	0.001004
2	101.6	1.0078	0.002016
4	208.2	1.0158	0.004063
6	307.5	1.0198	0.006119

PRESSURE OF GASES

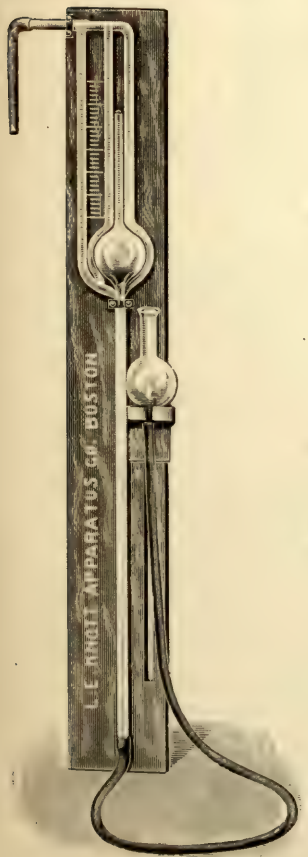
GAUGES — PRESSURE AND VACUUM BOYLE'S LAW APPARATUS BAROMETER TUBES

No. 41–60

No. 41–70

41–60 PRESSURE GAUGE, for steam or air pressure, graduated and tested by most improved instruments, warranted correct. Enclosed in iron case with nickel-plated ring, diameter of dial 3 inches, for pressures up to 150 pounds **$3.75**

41–65 VACUUM GAUGE, same quality as above, tested and graduated to read a vacuum from 0 to 30 inches of mercury. Enclosed in iron case with nickel-plated ring, diameter of dial 3 inches **3.30**



No. 41–80

41–70 COMBINATION PRESSURE AND VACUUM GAUGE, highest quality, for reading both pressure in pounds per square inch, and vacuum in inches of mercury.

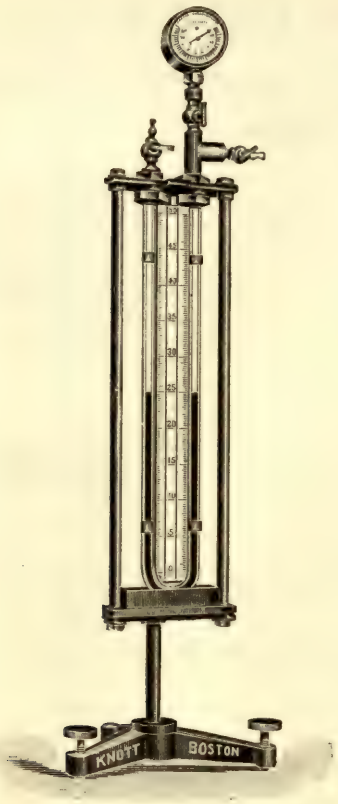
This instrument is furnished in handsome nickel-plated case and mounted on tripod stand, provided with stop-cock. It may be used under a bell glass on a pump plate or connected directly by tubing to a pressure or vacuum chamber. This gauge has a glass front and a glass back permitting a full view of its mechanism. Diameter of dial 4½ inches, graduated to read 0 to 75 pounds per square inch (approximately 150 pounds pressure) and 0 to 30 inches **$9.25**

41–72 COMBINATION PRESSURE AND VACUUM GAUGE, same structure as No. **41–60,** but graduated to read as No. **41–70.** Diameter of dial 4½ inches **6.65**

41–80 MACLEOD VACUUM GAUGE, for exact determinations of vacua.

This instrument is indispensable for exact determinations in high vacua and will register as high a vacuum as $\frac{1}{50,000}$ of a millimeter.

Mounted as illustrated, on neat hard wood board, with scale and adjustable support for reservoir . . . . . Duty Free **15.75**



No. 41–100

No. 41–105

41–100 BOYLE'S LAW APPARATUS, for the accurate determination of Boyle's Law up to ten atmospheres of pressure.

This apparatus is substantially built throughout, all parts accurately fitted to perform their functions and to withstand even the maximum pressure of ten atmospheres. It consists of a frame mounted on an upright support. This frame holds a sensitive manometer with a carefully graduated scale with clear and distinct graduations and figures. The pressure is introduced through the stop-cock shown at the left and indicated by the small pressure gauge shown at the top.

This instrument is handsomely finished, occupies but little space, being but 1 meter high, and is capable of very accurate determinations . . . . . Duty Free **$24.50**

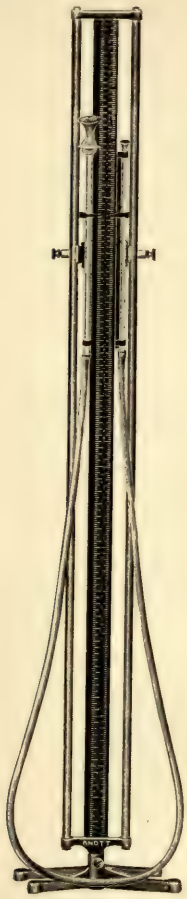
41–105 ADJUSTABLE SCALE BOYLE'S LAW APPARATUS, after Crew and Tatnall's "Laboratory Manual of Physics," Exercise 37, for determining Boyle's Law of pressures ranging between one-half and two atmospheres.

This apparatus must not be confused with the various types on the market. The prevailing error of these types is the leakage about the reservoir. We have obviated all danger of this error by a rubber stopper through which pass the glass tubes which are held more securely the greater the pressure. In fact, our adjustment of this cap prevents all loss by leakage. Attached to and cast as a part of the receptacle is an upright to which is fastened the wooden support backing for the meter rod. This backing carries small clamps which hold the tubes in place. The meter rod is held adjustably by means of thumb nuts to this backing. The whole is mounted on neatly japanned tripod base. In operation, the apparatus requires some form of compression pump which is attached by rubber tubing to the bent glass tube noted in the illustration.

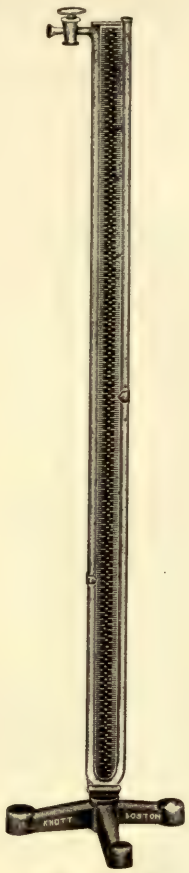
Complete as illustrated without compression pump **4.95**

41–106 COMPRESSION PUMP, especially adapted for use with above . . . . . **.25**

HAND AIR PUMP, recommended for use with No. **41–105** Boyle's Law Apparatus. For description and illustration, see Section **42.**



No. 41–110



No. 41–113

No. 41–115

41–110 ONE HUNDRED AND FIFTY CENTIMETER BOYLE'S LAW APPARATUS, ADJUSTABLE FORM, for the determination of Boyle's Law.

The apparatus consists of a metal frame with scale mounted on our H Base, the tube carriers consisting of wooden strips attached to special clamps in such a way that there is a perfect alignment at all times relative to the scale. Each tube is provided with a movable brass indicator for registering the heights of the columns of mercury. Instead of the tube with the closed end, we are supplying a tube closed with an air-tight glass stop-cock. This apparatus stands some 150 centimeters high, and being mounted on our special design H Base, is extremely rigid. It is handsomely finished in japan and nickel-plate.

Complete as illustrated $9.00

41–113 KNOTT'S ADJUSTABLE SCALE BOYLE'S LAW APPARATUS, for determining Boyle's Law.

This form of apparatus consists of Miller's Pressure Tube (see Section **60**) mounted on Adjustable Scale Support as described in the following item, No. **41–115.** The use of this apparatus requires some efficient form of Air Pump. No. **42–75** is highly recommended.

Complete as illustrated 3.85

41–114 MILLER'S COMBINATION PRESSURE GAUGE, tube only unmounted 2.00

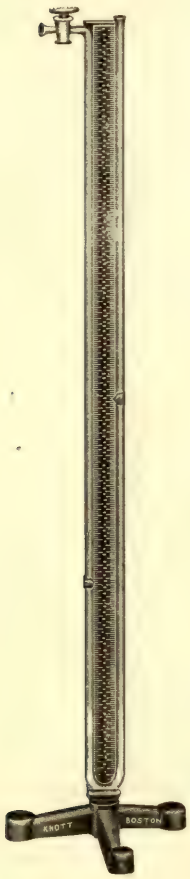
41–115 SIMPLE ADJUSTABLE SCALE BOYLE'S LAW APPARATUS, for the derivation of the law that the product of the Volume of a Gas by its pressure is a constant quantity.

In this, our new form, we have striven to correct mistakes of old types and enhance the value of an inexpensive Boyle's Law Stand. Our stand consists of a finished hardwood backing attached to a casting, which, in turn, is threaded into a neatly finished tripod base. Our improvement obviates the use of cumbersome clips, rubber bands, etc. The tube may be attached or removed in an instant from the above-mentioned wooden back, one sliding brass clip, which also answers the purpose of an indicator, being the only fastening device.

Complete with simple J tube, as illustrated 2.85

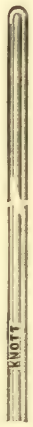
41–116 ADJUSTABLE SCALE BOYLE'S LAW STAND. Stand only, as used in above 1.85

41–120 BOYLE'S LAW TUBE, simple J form, as used in No. **41–115** 1.00



No. 41–113

No. 41–150



No. 41–155

No. 41–157

41–113 BAROMETER DEMONSTRATION APPARATUS consisting of Miller's Pressure Tube (See Section **60**) mounted on our adjustable scale support as described in No. **41–115**.
In use the stop-cock is left open until the tube has been completely filled with mercury when it is then closed. The mercury will then fall to the point of barometric height.
Complete, as illustrated **$3.85**

41–150 BAROMETER OR TORRICELLIAN TUBE AND GILLEY MERCURY WELL for demonstrating atmospheric pressure; also illustrating the Torricellian Vacuum.
This consisits of a heavy walled tube, 80 centimeters long, closed at one end, the open end being flared to allow introduction of mercury. The mercury well is a metal casting, cored to produce internal dimensions calculated to use the least amount of mercury and to facilitate the introduction of the open end of the barometer tube.
Barometer Tube and Well, as illustrated . . . . . **.80**

41–152 STAND WITH CLAMP for clamping the barometer tube in upright position.
This stand consists of a neat tripod base, with nickel-plated rod. The clamp for holding the tube has cork-lined jaws and is swiveled so that it can be clamped at all angles as well as adjustable within short lengths from the rod **1.10**

41–155 BAROMETER TUBE, heavy walled glass tube 80 centimeters long, closed at one end . . . . . **.45**

41–157 BAROMETER TUBE, graduated, for use when quantitative measurements are desired. This tube is graduated throughout the entire length to millimeters from zero at the open end of the tube . . . **2.00**

41–160 GILLEY MERCURY WELL as described in No. **41–150** . . . . . **.35**

AIR PUMPS

VACUUM PUMPS COMPRESSORS ASPIRATORS

No. 42–15

42–10 THE RITCHIE STANDARD PUMP. Lever action. Brass plate, especially prepared by our new process. Brass cylinder of the most accurate construction.
SIZE. Cylinder 2¼ inches diameter, 7-inch stroke. Brass plate, 10 inches diameter.
VALVES. No pump valve has yet been designed which will produce better results under all laboratory conditions than that made by E. S. Ritchie, a form of valve which we use exclusively in this class of pump.
MOUNTING. A substantial 2-inch mahogany base and upright, oil finished to withstand rough wear in the laboratory.
Price **$33.25**

42–15 THE RITCHIE SUPERIOR PUMP. Lever action, the same style, size and finish as the above, except that the plate is equipped with insulated binding posts on the base as illustrated. These binding posts will be found of very great service in experiments on sound in a vacuum and other experiments where the insulation need not necessarily stand high tension currents.
A most complete and satisfactory pump for general use in the physical laboratory.
Price **35.50**

42–75 HAND AIR PUMP, CONDENSING AND EXHAUSTING, for general utility in laboratory practice where a relatively small vacuum pressure is desired.
This is a simple pump with valve for both compression and exhaustion, and has a cylinder one inch in diameter by 11½-inch stroke. The lower end is drilled and tapped to receive our Air Pump Attachment, which in use requires No. 5–1000 Universal T-beam "Basic Clamp" A. This Pump Attachment is made in two parts and is held together by a friction joint which allows the setting of the pump to any angle in one plane. It is provided with a nickel-plated T-screw for securing to the Basic Clamp.
Complete as illustrated, without Basic Clamp **4.00**

5–1000 BASIC CLAMP **1.15**

No. 42–75

THE INSTITUTE OIL-SEALED HIGH VACUUM PUMP

For work requiring the highest vacuum, the oil-sealed pump has been very generally recognized. The defects as well as the strong points of the old form of oil pump have been very carefully studied during the past two years, with the result that we are able to offer a pump in which the defects of the older pumps have been entirely eliminated. Our new type is rapid in action and guaranteed not to squirt oil from the cylinder. This latter difficulty has been common heretofore in practically all of the oil pumps on the market. Our pump is also capable of an extraordinarily high degree of vacuum.

TESTS. The test which we have found most practical is the electrical discharge in the exhausted chamber, and no pump passes our inspection department until it has produced a satisfactory X-Ray vacuum.

OPERATION. The operating part consists of a substantial metal cylinder alternately raised and lowered into a fluid chamber filled with oil of the lowest possible vapor tension. This action results in a Torricellian vacuum being produced in the cylinder at each stroke. At the proper place in the stroke the air is allowed to flow from the chamber being exhausted into the cylinder, and the operation is thus continued.

It will be noted that we obtain in a single cylinder all the advantages of two cylinders in tandem frequently used by manufacturers of oil pumps. This is made possible from the fact that air taken from the lower side of the cylinder to produce the Torricellian vacuum in the lower chamber is forced into the upper chamber, from which it is in turn expelled, a Torricellian vacuum being formed in the upper portion of the chamber.

It will thus be seen that the degree of vacuum depends upon the vapor tension of the fluid used.

CONSTRUCTION. The simplicity of design enables all parts to be of a most substantial construction. The absence of delicate valves to become worn and thrown out of adjustment insures the continued operation of the pump and its dependable qualities.

FEATURES

VACUUM. A Torricellian vacuum is produced within the cylinder at each stroke. All parts being at the time flooded with oil, it is seen that the degree of vacuum is entirely independent of the nicety of fitting of the various parts, making possible the most substantial construction and insuring against wear when subject to continued use.

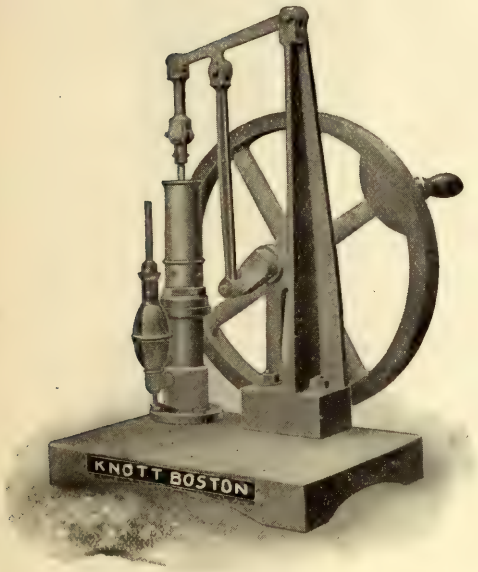
SIZE. To meet conditions as they exist in the majority of laboratories we offer this pump in two sizes. Rapidity of exhausting and price are the factors which will determine the selection.

MOUNTING. The pumps are provided with the most substantial mounting in the same general form as is shown in illustration No. **42–15.**

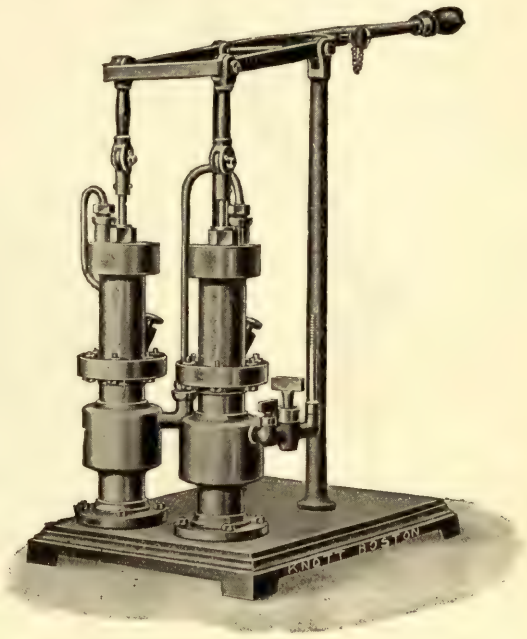
THE GERYK VACUUM PUMPS

The well-known Geryk Pumps merit the cordial favor with which they have been received in this country. Because of the greater variety of sizes in which they are made, we continue to list the ten most common, with the belief that in some laboratories other sizes than those furnished in our Institute design herewith listed may be found more useful.

OIL SEALED VACUUM PUMPS



No. 42–30a



No. 42–34

THE INSTITUTE OIL SEALED PUMP

(For illustration see No. 42–15.)

42–20 **INSTITUTE OIL SEALED PUMP "A,"** cylinder 2⅛ × 5 inches **$23.00**

42–25 **INSTITUTE OIL SEALED PUMP "B,"** cylinder 2½ × 8 inches **45.00**

GERYK VACUUM PUMPS

42–30 **"GERYK" VACUUM PUMP,** 1½-inch cylinder by 5-inch stroke, fitted with a 7-inch carefully ground plate . . . . . Duty Free **$30.00**

42–30a ——, same as above, without plate . . . . . Duty Free **28.50**

42–31 ——, 2-inch cylinder by 5-inch stroke . . . . . Duty Free **33.25**

42–32 ——, 2-inch cylinder by 10-inch stroke . . . . . Duty Free **48.00**

42–33 ——, 2½-inch cylinder by 10-inch stroke . . . . . Duty Free **78.50**

42–34 **"DUPLEX GERYK" VACUUM PUMP,** 2-inch cylinders and 5-inch stroke . . . . . Duty Free **95.00**

42–35 **"DUPLEX GERYK" VACUUM PUMP FOR POWER,** 2-inch cylinders and 5-inch stroke Duty Free **122.50**

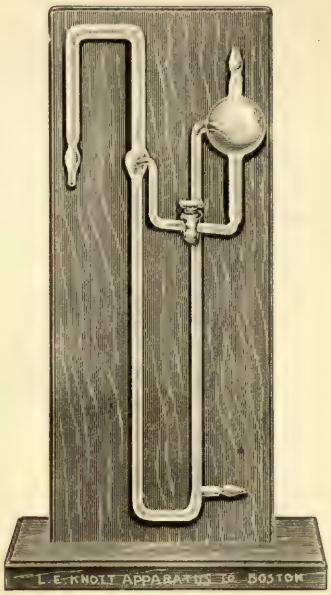
42–36 ——, 2½-inch cylinders by 5-inch stroke . . . . . Duty Free **158.00**

42–37 **"DUPLEX GERYK" VACUUM PUMP,** 3-inch cylinders by 7-inch stroke . . . . . Duty Free **245.00**

42–38 ——, 3½-inch cylinders by 7-inch stroke . . . . . Duty Free **324.00**

42–45 **TORRENTIUM OIL FOR HIGH VACUUM WORK.** For the best results with oil-sealed pumps, especially prepared oil having both the right viscosity and vapor tension is required. To meet the requirements of our own Institute Pumps as well as for those of the Geryk design, we have arranged to have supplied to us a special oil prepared to meet the most exacting demands of high vacuum work.
The price is of necessity somewhat higher than for oils of commercial grade, but the amount required for each pump is so small that the expense is nominal . . . . . Per Quart **1.25**

No. 42–75



No. 42–100

42–75 **CONDENSING AND EXHAUSTING HAND AIR PUMP WITH SWIVEL** for general utility in laboratory practice where a relatively low vacuum or pressure is desired.

This is a simple pump with valve for both compression and exhaustion and has a cylinder 1 inch in diameter by 11½ inch stroke. The lower end is drilled and tapped to receive our air pump attachment which, in use, requires No. **5–1000** Universal T-beam Basic Clamp "A." This pump attachment is made in two parts and held together by a friction joint which allows the setting of the pump to any angle in one plane. It is provided with a nickel-plated T-screw for securing to the Basic Clamp.

Complete as illustrated, without Basic Clamp **$4.00**

5–1000 **BASIC CLAMP** **1.15**

43–120 **AIR PUMP PLATE,** 10-inch diameter, surface carefully ground true **4.90**

42–100 **BOLTWOOD MERCURY PUMP,** an inexpensive automatic mercury pump requiring only a small amount of mercury.

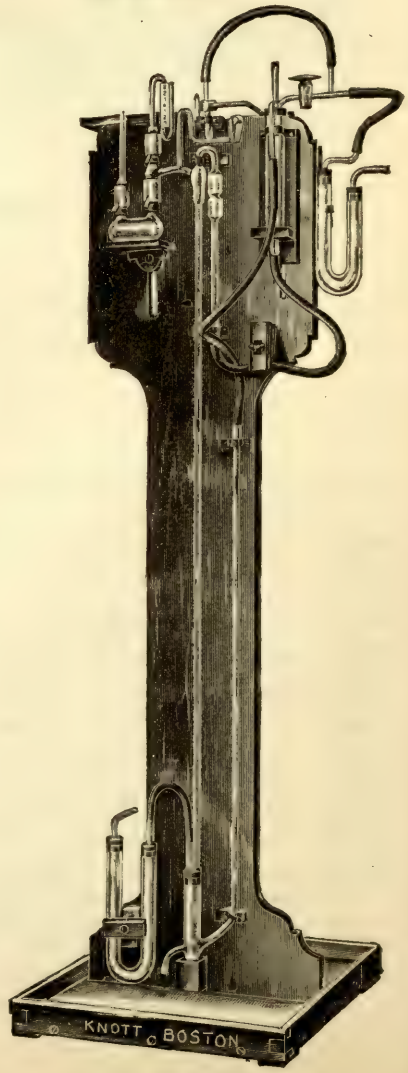
This pump is practically automatic in its action and is continuously operated by a small aspirator. It is rapid in action and will exhaust a liter flask sufficient for any ordinary work in twenty minutes.

Mounted on neat wooden stand **11.25**

42–102 ——, same as above, without stand **9.00**

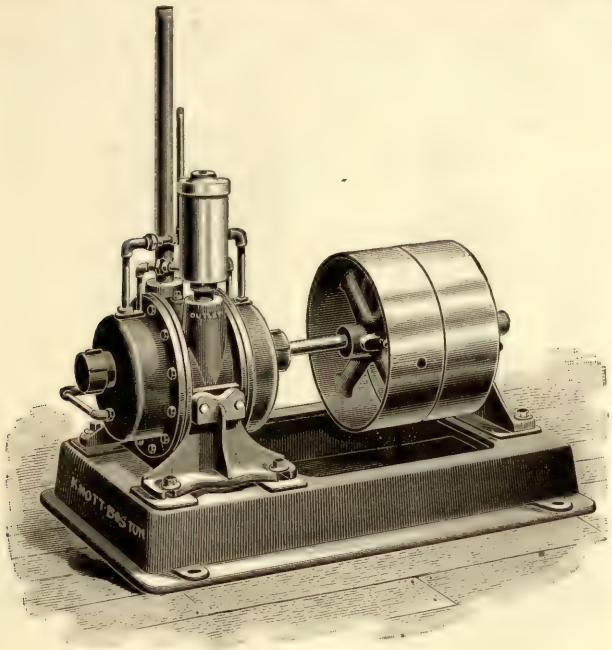
42–105 **SELF-ACTING SPRENGEL'S MERCURY AIR PUMP.** This pump, of European manufacture, has been highly recommended both for its efficient action as well as for its automatic qualities.

Complete on substantial, highly polished wood mount with all accessories illustrated . . . . . Duty Free **48.75**



No. 42–105

ROTARY COMPRESSION OR VACUUM PUMP



No. 42–110

The idea of these rotary pumps is comparatively new, and, from their construction, are designed to fulfil all the usual requirements of a compressor or a vacuum pump. For many purposes they are unexcelled. Besides presenting a mechanical and handsome appearance, these pumps have the following features which are highly recommended.

The in-take and delivery of air is continuous and does not depend upon valves or springs of any form.

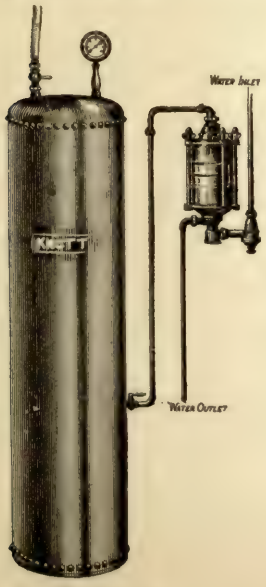
The simplicity and facility with which they may be set up and operated.

The small floor space and the light power required.

The positive lubrication secured by simple automatic lubricator.

The efficient cooling by special water jackets.

The high degree of efficiency possible: — a pressure capacity of 25 to 30 pounds per square inch when used as a compressor; as a vacuum pump, maintaining most any vacuum possible, under local conditions of the atmosphere, up to 90 per cent.



No. 42–120

42–110 ROTARY COMPRESSOR OR VACUUM PUMP, capacity 15 cubic inches per revolution. Pulleys, 6 inches in diameter, 2-inch face . **$55.00**

42–112 ROTARY COMPRESSOR OR VACUUM PUMP, capacity 40 cubic inches per revolution. Pulleys, 8 inches in diameter, 2-inch face . **77.00**

42–114 ROTARY COMPRESSOR OR VACUUM PUMP, capacity 100 cubic inches per revolution. Pulleys, 12 inches in diameter, 4-inch face . **112.00**

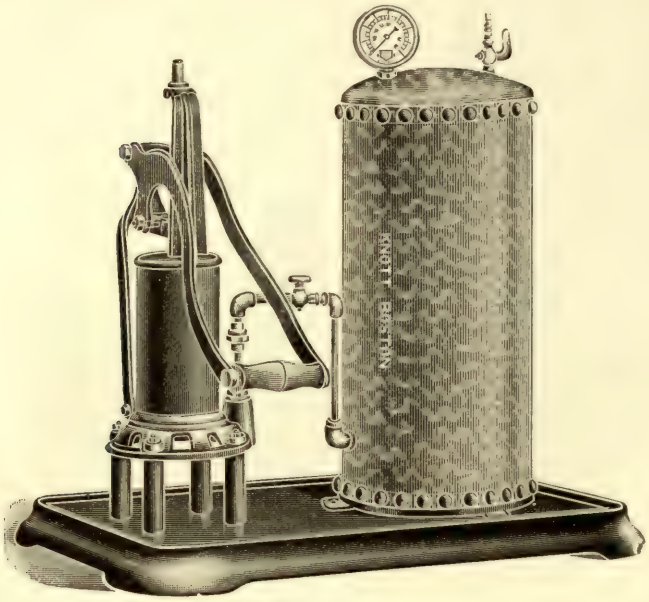
42–120 HYDRAULIC COMPRESSOR for securing a moderate supply of compressed air.

This compressor can be easily attached to any water faucet or supply pipe and air be kept on tap at all times. The action of the compressor is automatic, the slightest change in the pressure operating a a pressure regulator which causes the pump either to start or stop. Water is not wasted by running in while discharging nor is force impaired by lifting weights, so that a pressure equivalent to that of the city supply can be maintained up to 30 pounds.

The complete outfit consists of a 24-gallon tank, hydraulic compressor, pressure gauge, pressure regulator, and cock.

Price complete **58.00**

42–122 HYDRAULIC COMPRESSOR only, of above **31.00**



No. 42–135

42–135 COMPRESSED AIR OUTFIT for securing a delivery of air under pressure.

The compression pump above illustrated is designed especially for hard service. The compound lever is of new form permitting of the best application of power and rendering the work comparatively easy. The cylinder and base are cast of one piece bored and reamed to accurate size. This construction with piston and valve accurately fitted, insures a high efficiency. Diameter of cylinder 3¼ inches, stroke 5½ inches, displacement per stroke 45.6 cubic inches, working pressure 100 pounds.

This pump is direct connected to a five-gallon galvanized iron tank guaranteed air-tight and provided with all necessary cocks and pressure gauge.

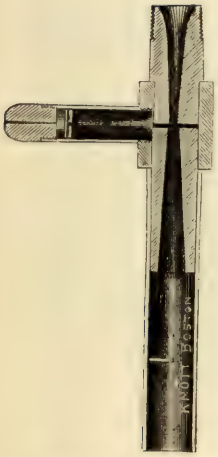
Pump and tank are rigidly fastened to a special cast-iron base, 25 × 17 inches.

With this outfit pressure up to 40 pounds can be readily secured and if desired as high as 100 pounds, — the working pressure of pump and of tank.

Schools desiring an inexpensive yet highly efficient compressed air service will find this one of great value.

Complete, mounted as illustrated with all necessary attachments **$35.00**

AIR PUMP ACCESSORIES



Nos. 42–150 and 42–160

Nos. 42–152, 42–162, and 42–177

Nos. 42–153, 42–163, and 42–178

No. 42–175

No. 42–19

42–150 **CHAPMAN'S ASPIRATOR** for reduction of air pressure by water aspiration. This aspirator is of brass, 4 inches long, ⅛ inch I. P. size thread, giving a capacity of 5 cubic feet per hour **$1.25**

42–152 **HYDRANT COUPLING** for use in connecting our **No. 42–150** to ¾-inch hose faucet . . . . . **.30**

42–153 **HYDRANT COUPLING** for connecting our No. **42–150** to a smooth faucet. These couplings cannot leak or be forced off . . . . . **.50**

42–160 **CHAPMAN'S ASPIRATOR,** similar to No. **42–150,** but with capacity of 18 cubic feet per hour. Length 5 inches; ¼ inch I. P. size thread **1.70**

42–162 **HYDRANT COUPLING** for use in connecting our No. **42–160** to ¾-inch hose faucet . . . . . **.30**

42–163 **HYDRANT COUPLING** for use in connecting our No. **42–160** to a smooth faucet. These couplings cannot leak or be forced off . . . . . **.50**

42–175 **RICHARD'S ASPIRATOR,** a more powerful and efficient filter pump than Nos. **42–150** and **42–160.** Length 7 inches; ⅜ inch I. P. size thread **1.70**

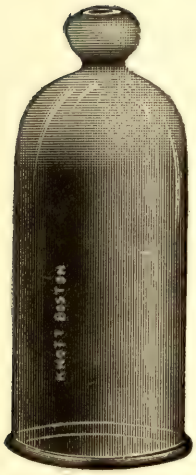
42–177 **HYDRANT COUPLING** for use in connecting our No. **42–175** to ¾-inch hose faucet . . . . . **.30**

42–178 **HYDRANT COUPLING** for use in connecting our No. **42–175** to a smooth faucet. These couplings cannot leak or be forced off . . . . . **.50**

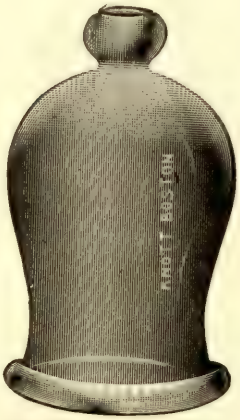
42–190 **MUENCKE'S ASPIRATOR,** entirely of glass, total length 8½ inches. As all parts are visible, this is a convenient demonstration instrument **1.00**

BELL GLASSES

CLEAR, WHITE GLASS, FLANGES GROUND AND TESTED



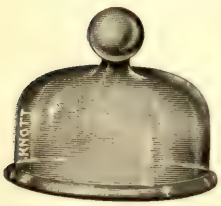
Nos. 43–25 to 43–27



Nos. 43–35 to 43–40

No. 43–50

No. 43–60



Nos. 43–65 to 43–67

No. 43–70

No. 43–75

No. 43–80

43–25 **STRAIGHT FORM BELL GLASS, WITH KNOB TOP.** Capacity 1 gallon, inside height 11 inches, diameter 6 inches **$1.00**

43–27 ——, same as above, capacity 2 gallons, inside height 15 inches, diameter 7 inches **1.90**

43–35 **SWELLED FORM BELL GLASS, WITH KNOB TOP.** Capacity 2 gallons, inside height 12 inches, diameter 7 inches **1.65**

43–37 ——, same as above, capacity 3 gallons, inside height 13 inches, diameter 8½ inches **2.60**

43–40 ——, same as above, capacity 5 gallons, inside height 15 inches, diameter 10 inches **6.30**

43–50 **STRAIGHT FORM BELL GLASS, WITH GLASS STOPPER.** Capacity 1 gallon, inside height 11 inches, diameter 6 inches **1.60**

43–60 **STRAIGHT FORM BELL GLASS, NECK FOR CORK STOPPER.** Capacity 1 gallon, inside height 11 inches, diameter 6½ inches **1.10**

43–65 **LOW FORM BELL GLASS, WITH KNOB TOP.** Inside height 2¼ inches, diameter 4 inches . . . **.57**

43–67 ——, same as above, inside height 4 inches, diameter 6 inches . . . . . **.90**

43–70 **HAND AND BLADDER GLASS,** swelled form, both flanges ground and tested, medium size . . . **.90**

43–75 **BELL GLASS,** special mold, ground flange, re-enforced neck for our No. **30** rubber stopper. Inside height 4 inches. This bell glass in used with a one-hole rubber stopper and a barometer tube to perform the experiment of No. **43–80** **1.25**

43–80 **BELL GLASS,** straight sides, about 3 feet high, flange ground and tested for use with No. **41–150** Barometer Tube and Well, to show successive diminution in pressure when placed on the plate of an air pump.
Complete as illustrated, with No. **41–150** Barometer Tube and Well **3.85**

43–82 **BELL GLASS** only, of above **3.05**

Nos. 43–110 to 43–112

AIR STORAGE TANKS, for the storage of air or non-corrosive gases under pressure. These tanks are made of heavy galvanized iron and guaranteed to be absolutely air-tight, under a guaranteed test of 150 pounds and for a working pressure of 100 pounds.

43–110 **AIR STORAGE TANK,** capacity 2½ gallons, size 6 inches diameter by 20 inches high **$6.65**

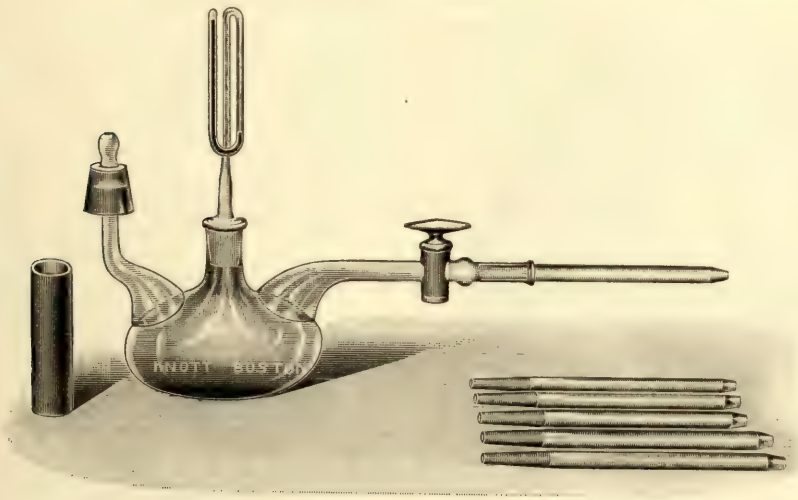
43–111 ——, capacity 5 gallons, size 9 inches diameter by 20 inches high . . **7.40**

43–112 ——, capacity 12 gallons, size 10 inches diameter by 33 inches high . **8.90**

PRESSURE GAUGE. See No. **41–60.**

No. 43–120

43–120 **AIR PUMP PLATE,** diameter 10 inches, vent hole tapped for all air pump accessories, surface turned true and carefully ground plane. Mounted on substantial tripod base and provided with guard plug and stop-cock **$4.90**



No. 43–130

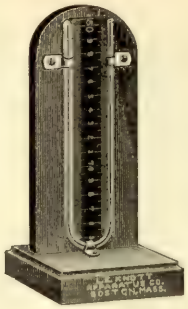
43–130 **DRYING APPARATUS,** for removing moisture in high vacuum work.

This apparatus is for use with concentrated sulphuric acid and is provided with a ground-on manometer and two projecting tubes, one for holding a brass tube connection for attachment to the air pump, the other with a stop-cock. The end of this stop-cock tube is provided with a ground socket into which different tubes with tapering ground ends may be held in air-tight junction. The vessel to be exhausted can be sealed to these tubes.

Apparatus complete as illustrated, with six tubes . . . . . Duty Free **$9.25**

No. 43–140

No. 43–145

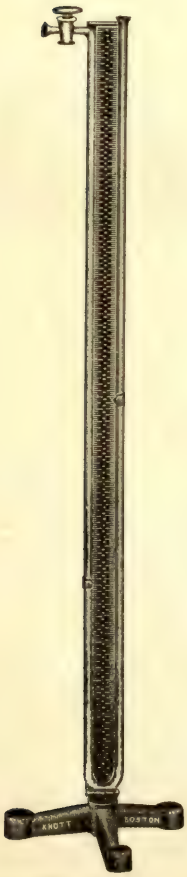


No. 43–150

43–140 MANOMETER, for attachment to air pump to denote degree of exhaustion.
This is an instrument carefully constructed and handsomely finished for attachment to the guard or vent hole to denote the degree of exhaustion. It consists of a metal casting, threaded to fit any hole threaded 7/16 by 16. Attached to this casting is a black oxidized metal scale filled in white holding a manometer tube. This scale and tube are encased in a heavy glass cover.
This instrument will be found efficient, rapid, and a valuable accessory in the study of Pneumatics . . **$6.15**

43–145 MOVABLE SCALE MANOMETER, mounted on neat wooden support stand, to determine the degree of exhaustion in experiments in Pneumatics.
This is an improved form of manometer with glass stop-cock which is mounted with a movable scale support supporting the mirror glass scale on a neatly finished wooden stand **4.50**

43–150 SIMPLE MANOMETER, consisting of a U-tube mounted with scale on a neatly finished wooden stand **1.70**



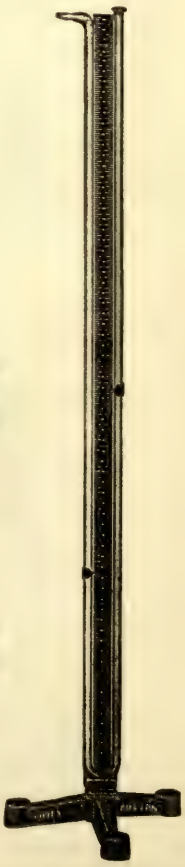
No. 41–113

41–113 MILLER'S COMBINATION PRESSURE GAUGE, for registering high pressures.
This is a tube, 1 meter in height. Our illustration shows it mounted on our No. **41–116** Boyle's Law stand. One arm of this tube is provided with a stop-cock so that the instrument may be used as a Boyle's Law Tube as well as a Barometer. In use as a Pressure Tube, however, this stop-cock must be left open. In use as a Barometer, the stop-cock is left open until the tube has been completely filled, when it is closed. The mercury will then fall to the point of barometric height. Complete as illustrated, with stand **$3.85**

43–114 MILLER'S COMBINATION PRESSURE GAUGE. Tube only, unmounted **2.00**

43–170 PRESSURE GAUGE, as designed by Messrs. Turner and Hersey.
This gauge has been especially designed for registering high pressures, the length facilitating this use. It must be used, however, on some form of stand. Our illustration shows it in use mounted on our No. **41–116,** a description of which will be found under No. **41–115.**
Complete, as illustrated, with stand **3.20**

43–171 PRESSURE GAUGE. Tube only, unmounted . . . **1.35**



No. 43–170

No. 43–200

No. 43–202

No. 43–204

No. 43–206

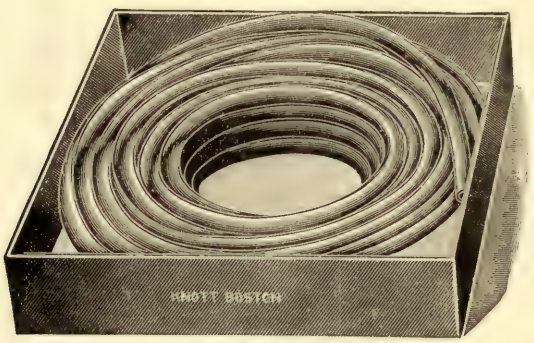
43–200 **BRASS COUPLING,** threaded to fit our air pumps and air pump accessories. Carefully made in our own factory **$0.33**

43–202 **BRASS STOP-COCK,** double male screw, threaded to fit our air pumps and air pump accessories; ⅛ inch bore. Carefully made in our factory . . . . . **.68**

43–204 **BRASS NIPPLE,** female screw, threaded to fit No. **43–202** Stop-cock or No. **43–200** Coupling, or any of our air pumps and air pump accessories. Carefully made in our own factory . . . . . **.33**

43–206 **BRASS GUARD PLUG,** threaded to fit our air pumps. Carefully made in our own factory . . . . **.33**

No. 43–210



No. 43–217

43–210 **PUMP OIL AND CAN.** This combination will recommend itself to many teachers who require an efficient lubricator.
The can is of special design, with screw stopper. Four-ounce size filled with best quality of oil. . . **$0.35**

43–215 **PHOSPHORUS PENTOXIDE** for absorption of moisture in high-vacuum experiments. Sealed bottle, containing 1 ounce . . . . . **.65**

43–217 **VACUUM TUBING.** This is a specially prepared heavy-walled reinforced rubber tubing, 5/16 inch diameter, obviating leakage in making air-tight connections . . . . . Per Foot **.20**

43–220 **RUBBER DAM OR THIN RUBBER SHEETING,** especially useful in illustrating the crushing force of atmospheric pressure . . . . . Per Square Foot **.33**

43–221 **PARCHMENT,** good quality, adapted for demonstrating the crushing force of atmospheric pressure Per Sheet **.18**

43–225 **LEATHER WASHERS,** for use with stop-cocks, plugs, etc. ¾ inch diameter by 7/16 inch hole. Per Doz. **.25**

No. 43–230

43–230 RUBBER BAG for experiments in pneumatics. This bag is of light rubber of the best quality and is furnished complete with outlet tube and screw pinch-cock **$1.15**

No. 43–240

No. 43–245

No. 43–247

No. 43–250

43–240 FOUNTAIN IN VACUO, illustrating atmospheric pressure. This apparatus consists of a vessel molded conical in form after our own mold. The lower open end is closed air-tight by means of a cup-shaped brass casting and stop-cock and is mounted on one of our japanned iron tripods.

In use, the tripod is removed and the apparatus is screwed to the center of the pump plate. The stop-cock is then turned and air exhausted from the vessel. If now the apparatus is again mounted on the tripod and placed in a dish of water, the pressure of the atmosphere will force the water into the vessel showing a very vigorous fountain as soon as the stop-cock is opened.

Complete, as illustrated **$4.00**

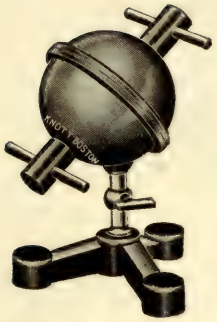
43–245 DEMONSTRATION WATER HAMMER, for showing that water or any liquid will fall as a solid in a vacuum.

This apparatus consists of a tube 16 inches in length the open end of which is closed by a brass cap fitted with a brass stop-cock.

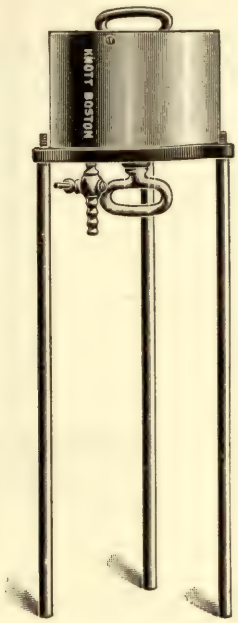
In use, the air is exhausted from the tube and the end held under water and stop-cock opened. Water is allowed to be forced by atmospheric pressure until about ¼ full. If tube is now inverted, the water will fall as a solid mass, the tube emitting a distinct sound as if struck by a blow **2.50**

43–247 WATER HAMMER, illustrating that water will fall as a solid in vacuo. This consists of a tube, 30 centimeters in length, partially filled with water in a vacuum. With one bulb . . . . . **.65**

43–250 TWO BULB SINGING WATER HAMMER, arranged so that the water falling in vacuo will emit pleasing tones in addition to the metallic click **2.15**



No. 43–255



No. 34–40

43–255 MAGDEBURG HEMISPHERES, for demonstrating atmospheric pressure in all directions.

The apparatus consists of two cast, hollow hemispheres of metal, the edges of which are carefully ground smooth to make an air-tight junction. On one is cast a " boss " which is tapped for a brass stop-cock threaded to fit the air pump and also the tripod illustrated. Each hemisphere is provided with convenient handles. The whole is durably and handsomely finished.

In use, the hemispheres are removed from the tripod and stop-cock closed. It will be noted that the hemispheres separate readily. The stop-cock is then opened and air exhausted from the interior of the hemispheres. The stop-cock is then closed and hemispheres removed from the pump. Upon test it will be found that considerable force is needed to separate the hemispheres.

Complete, as illustrated **$4.45**

34–40 SEVEN–IN–ONE APPARATUS OR SPIROMETER, GAGE'S IMPROVED for demonstrating fundamental principles in pneumatics and hydraulics.

This apparatus consists of a seamless brass cylinder 6 inches in diameter, mounted on a metal casting, provided with bosses, into which rods may be screwed from either side. The cylinder is provided with an ingeniously designed piston which, owing to its construction, has greater efficiency the longer the use. This construction also obviates the sticking of the washers and leakage around them. Each instrument is provided with our detachable handle in the piston head, a fixed handle with brass stop-cock with nipple, a rubber tube, and funnel. This apparatus, as implied from the name " Seven-in-One," will illustrate the principles involved in seven different instruments, as follows: — Hydraulic Lift, Hydraulic Press, Incompressibility of Liquids Apparatus, Pascal's Law Apparatus, Pneumatic Lift, Hydrostatic Bellows, Magdeburg Hemispheres.

This instrument is handsomely finished in gold lacquer and nickel plate and is furnished complete with three nickel-plated rods **8.15**

No. 43–270

43–270 **MODEL OF A DIVING BELL,** demonstrating how, in a caisson, air is supplied to keep up life and to keep back the water.

The design above illustrated demonstrates, in a simple way, the principle of caissons. A conical-shaped glass vessel with metal mountings top and bottom has, at its top, a tube for supply of air which is forced into the vessel by means of an air pump. The bottom casting is designed to hold a slow-match as well as to support a weight. The whole is submerged in a jar of water as illustrated. The supply of fresh air through the tube keeps the spark on the slow-match alive. The whole is suspended in the jar by any convenient means.

Diving Bell, complete with weight, slow-match and special jar **$9.25**

The only item above illustrated not previously listed and not included above is:

43–271 **HARCOURT SPECIAL H BASE** for 19 millimeter rod **1.00**

Other items illustrated above and listed elsewhere are:

5–20b **SUPPORT ROD,** 40 centimeters long, 19 millimeters diameter **$0.52**

5–770 **RIGHT ANGLE CLAMP** . . . . . **.95**

5–950 **PULLEY MOUNTED ON ROD** . . . . . **.94**

No. 43–275

43–275 **BURSTING SQUARES APPARATUS,** illustrating the expansion of a gas; also, under normal conditions, the state of equilibrium existing in the atmosphere.

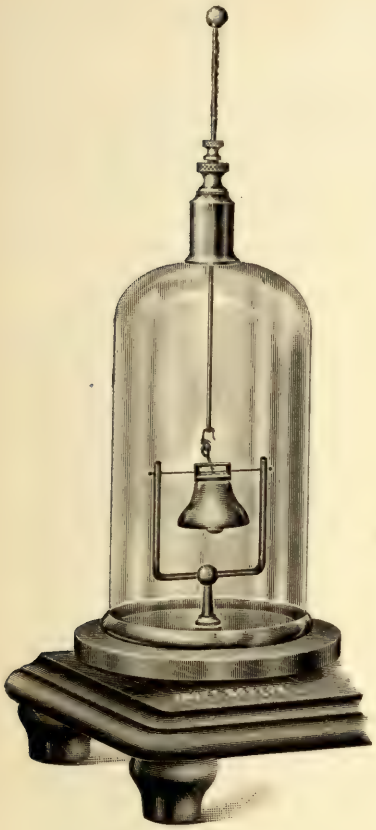
The apparatus consists of a bell glass with a small, closed, rectangular, thin glass receptacle covered as illustrated by a wire guard.

When placed on the plate of a pump, and air exhausted, the expansive force of the air will burst the square into small pieces, due to the destruction of the equilibrium of air pressure within and without the squares.

Apparatus complete as illustrated with extra bursting square **$2.00**

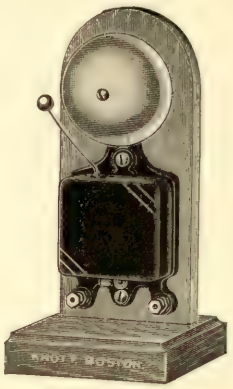
43–276 **BURSTING SQUARES,** as used in No. **43–275** . . . . . Per Dozen **2.45**

43–277 **WIRE GUARD,** as used in No. **43–275,** to protect the bell glass from the flying broken parts of the bursting squares. . . . . Each **.50**



No. 43–280

No. 43–285



No. 43–290

43–280 BELL IN VACUO APPARATUS illustrating non-transmission of sound in a vacuum.

This apparatus consists of a large-sized bell jar with brass cap, through the center of which slides a brass rod gripped air-tight by means of a packing screw. A bell suspended by a horizontal axis in a stirrup is supported over the vent in the center of the pump plate. This bell is rung by tipping through the agency of the sliding rod.

When placed on pump plate, as illustrated, if air is not exhausted, the bell, if tipped, will emit a distinct tone. If, however, the air is exhausted, the sound, though not absolutely lost, will be diminished to such an extent as to readily illustrate the non-transmission of sound in a vacuum.

Complete as illustrated, with Bell and Stirrup and Bell Glass with Sliding Rod. All brass parts polished and lacquered **$6.80**

43–282 BELL IN STIRRUP, as illustrated above **2.80**

43–283 BELL GLASS WITH SLIDING ROD, as illustrated above **4.00**

43–285 BELL IN VACUO illustrating non-transmission of sound in a vacuum.

This is a self-contained instrument supplied with a small nickel-plated bell suspended by springs to brass binding posts which are sealed in at top of a medium-sized bell glass. As the flange of this bell glass is carefully ground and tested and the vibration of the bell is deadened by suspending on springs, the non-transmission of sound is quite noticeable, the tone being almost lost in the vacuum.

Complete as illustrated **2.90**

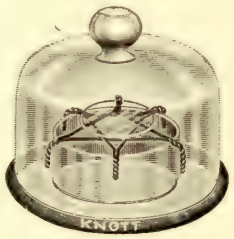
43–290 MOUNTED ELECTRIC BELL for use in connection with a bell glass and with our No. **42–15** Air Pump with electrical connections to illustrate non-transmission of sound in a vacuum.

Mounted as illustrated on neatly polished wooden upright **1.60**

43–25 BELL GLASS, straight form, with knob top, 11 inches high by 6 inches diameter **1.00**

No. 40–22

40–22 **BELL IN BAROSCOPE GLOBE** for the illustration of non-transmission of sound in a vacuum; also used to demonstrate the fact that air has weight.
This is a glass globe, 4¼ inches in diameter, fitted with brass cap and a stop-cock with hook, and has in its interior a small bell.
To demonstrate that air has weight, this globe is used as an ordinary baroscope globe; to illustrate non-transmission of sound, shaking the globe before and after exhaustion shows that the tingling of the bell is not heard, or heard only dimly, when the globe is in exhausted state **$5.40**



No. 43–310

43–310 **FREEZING APPARATUS,** illustrating freezing by the rapid evaporation of ether or other volatile liquids.
For description and illustration, see No. **62–165** **$1.40**

No. 43–325

43–325 **DEMONSTRATION ARC LAMP** forillustratingpassage of electric current through rarefied gases.
This apparatus consists of a bell glass with two lateral openings with brass caps, through the center of which pass the sliding rod carbon holders held in sliding grips by packing screws. These sliding rods are terminated by hard rubber handles and are provided with binding screws for attachment of electric current. As the bell glass is 10 inches in diameter, a pump plate of that size must be used with this instrument.
This apparatus is carefully made and the experiment, if properly conducted, is exceedingly instructive and the results spectacular.
Complete with extra pair of carbon pencils . . . . . Duty Free **$14.65**

43–326 **CARBON PENCILS** for use with above . . . . . Per Dozen **1.75**

BAROMETERS

The value of the Weather Bureau Type of Barometer has been realized in no small degree because of the large reservoir in which the height of the mercury is adjusted by means of the screw plunger at the bottom, the correct zero being indicated by a pearl white pointer projecting downward towards the surface of the mercury. This indicator being fixed, and the scale rigidly attached with reference to it, the level of the mercury is readily brought to the correct zero point before each reading. Many other methods of adjustment have been devised, but none have even approached this for accuracy and ease of operation.

No. 45–15

45–10 **FORTIN SCHOOL BAROMETER,** with cistern and method of adjustment, same as described above.

SCALE in both English and Metric system with clearly indicated divisions.

TUBE of generous proportions filled with greatest care.

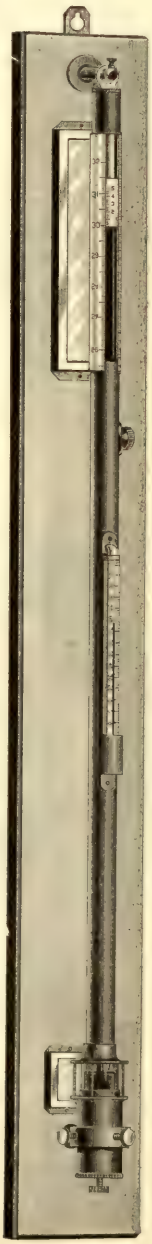
MOUNTING, well seasoned hardwood with rosewood finish, and protecting cap over the reservoir to prevent breakage, so designed as to permit clear view of both pointer and mercury in the reservoir $8.90

45–15 **FORTIN CISTERN SCHOOL BAROMETER WITH VERNIER,** double scale, double vernier, and thermometer. Scale reads from 24 to 32 inches with equivalent metric scale, reading with vernier to $\frac{1}{10}$ millimeter or $\frac{1}{100}$ inch . . 14.75

45–17 ——, same as above, but scale reading from 20 to 28 inches, with equivalent metric scale 18.75

45–20 **WEATHER BUREAU FORTIN BAROMETER,** with extra large mercury tube, cylindrical bulb mounted in oxidized brass, with insulating support and binding screws, thermometer with graduated stem scale, a thoroughly high grade instrument of a type used in all Weather Bureau Stations . 38.00

45–25 **MOUNTING BOARD** of mahogany, rosewood finish, supporting arm with locknut, dead white plate back of scale and mercury cistern, provided with screws for supporting in a vertical position 4.50



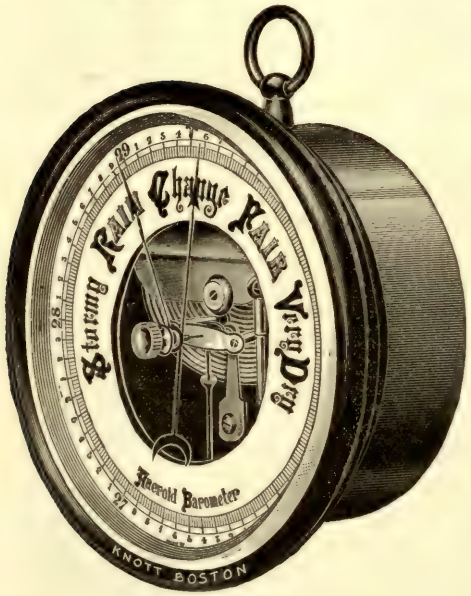
No. 45–20

No. 45–30

45–30 DEMONSTRATION ANEROID BAROMETER, desirable for the explanation and illustration of the mechanism of the ordinary Aneroid Barometer.

This instrument is ample in size for lecture room use and is particularly adapted to such use in that all parts are uncovered and can be distinctly viewed through a glass dome. Parts mounted on a polished hardwood base. Vacuum chamber connected with a length of rubber tubing which can be connected to small capacity air pump or demonstration more simply performed by blowing in or drawing out the air through the mouth. The varying pressure is readily shown by means of the indicating hand over the scale.

This instrument is a beautiful ornament and its construction is accurate enough for barometric observations **$13.25**



No. 45–40

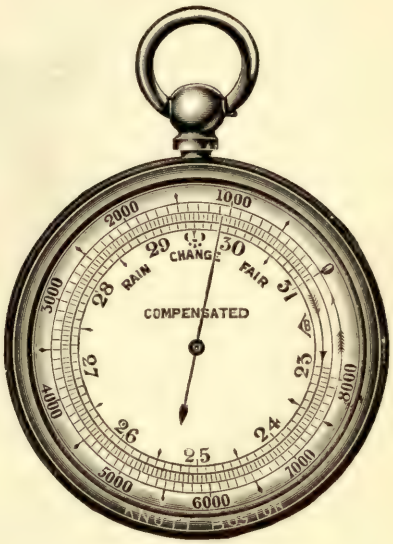
No. 45–50

45–40 ANEROID BAROMETER adjusted for altitudes up to 3500 feet, improved form, 4 inches in diameter, mechanism mounted in highly polished and nickel-plated brass case. Dial open that mechanism may be in full view. Graduations read in both the English and the Metric system **$4.00**

45–50 ANEROID BAROMETER adjusted for altitudes up to 3500 feet, brass case with closed silvered-metal dial 5 inches in diameter.

This barometer is improved by a patent altitude adjustment which consists of an auxiliary hand. This hand is adjustably attached to the pressure hand and moves with it. While the pressure hand shows the actual atmospheric pressure at the altitude at which the Aneroid is used, the patent adjustment hand may be so regulated as to show also the corresponding sea-level pressure . . . Each **8.00**

No. 45–55



No. 45–67

45–55 **HIGH ALTITUDE ANEROID BAROMETER.** The movements of this barometer are of good quality and in their general construction are identical to those illustrated in No. **45–50**; adjusted for use between 4900 and 9500 feet. Mechanism enclosed in polished brass case and open porcelain dial so that mechanism is in full view **$9.40**

45–57 ——, same as above, but of special design, most careful construction, and compensated for changes in temperature. Adjusted for use between 5950 feet and 11,800 feet. Mechanism enclosed in polished brass case with open silvered-metal dial. Mechanism in full view **17.25**

45–65 **POCKET MOUNTAIN ANEROID BAROMETER,** watch case form. This is a highest quality Aneroid, 1¾ inches in diameter, compensated for temperature, silvered-metal dial, revolving altitude scale. Enclosed in polished brass case. Adjusted to read to 3000 feet. Enclosed in neat morocco plush-lined case **14.75**

45–67 ——, same as above, but adjusted to read to 8000 feet **13.50**

45–69 ——, same as above, but adjusted to read to 10,000 feet **13.50**

45–71 ——, same as above, but adjusted to read to 16,000 feet **18.50**

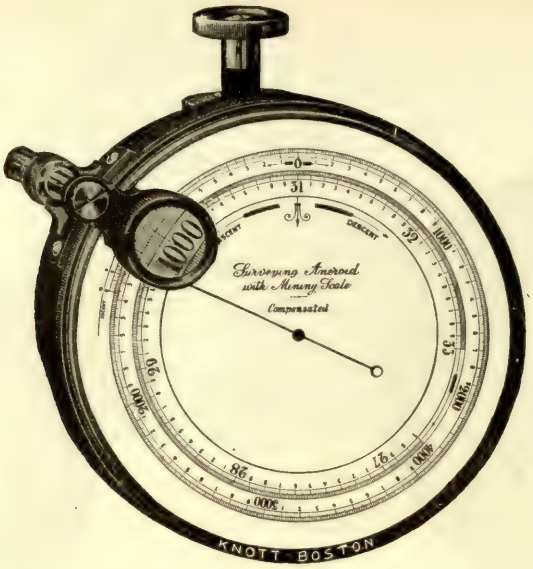
41–150 **BAROMETER or TORRICELLIAN TUBE and MERCURY WELL,** for demonstrating atmospheric pressure.

This consists of a heavy-walled tube 80 centimeters long, closed at one end, the open end being flared to allow introduction of mercury. The mercury well is a metal casting cored to produce dimensions calculated to use the least amount of mercury and facilitate the introduction of the open end of the Barometer Tube.

Barometer Tube and Well . . . . . **.80**

41–155 **BAROMETER TUBE,** heavy-walled, as used in above . . . . . **.45**

41–157 **GRADUATED BAROMETER TUBE.** This tube is heavy-walled, 80 centimeters long, closed at one end, the open end being flared to allow introduction of mercury. It is different from No. **41–155** in that it is graduated throughout its entire length to millimeters from 0 at the open end of the tube **2.00**

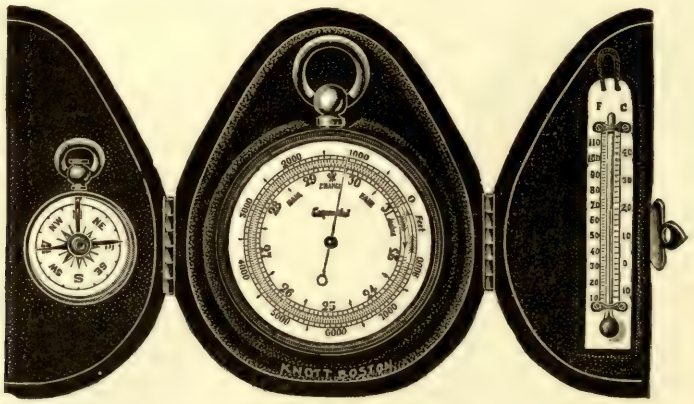


No. 45–80

45–80 SURVEYING ANEROID BAROMETER. These barometers have been especially constructed for the purpose of readily ascertaining slight variations in levels, etc. As readings may be taken to single feet of altitude scale its use for approximate surveys and levelings for roads, railways, canals, water courses, etc., is practically unlimited. Besides its extreme sensitiveness this instrument has in addition an arrangement of the scale of altitudes which admits of sub-divisions by a vernier, impractical in other types of Aneroid Barometers.

The mechanism is enclosed in a 3-inch stout bronze metal case, silvered-metal dial with vernier scale moved by rackwork motion, movable reading lens arranged to traverse the entire circle, with altitude scale adjusted accurately to 4000 feet.

This instrument is enclosed in a solid leather sling case . . . . . Duty Free **$38.50**



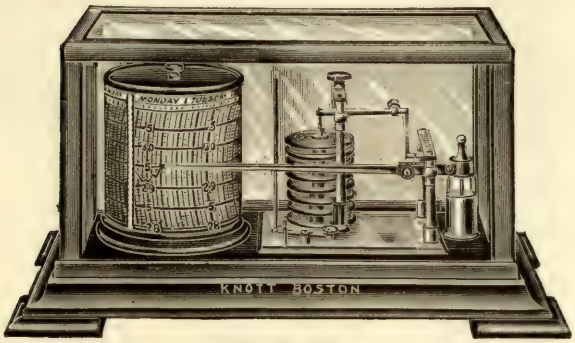
No. 45–85

45–85 TRAVELING SET, consisting of a 1¾-inch watch-case Aneroid with a revolving altitude scale adjusted to read 8000 feet in 50 foot divisions and compensated for temperature, a small-sized Compass, and a Thermometer.

Enclosed in a fine folding morocco case, designed to stand when desired . . . . . Duty Free **$26.50**

STANDARD TABLE OF ALTITUDES

Inch	Feet	Inch	Feet	Inch	Feet	Inch	Feet	Inch	Feet
31.00	0	28.28	2500	25.80	5000	23.54	7500	21.47	10000
30.43	500	27.76	3000	25.33	5500	23.11	8000	21.08	10500
29.88	1000	27.26	3500	24.87	6000	22.69	8500	20.70	11000
29.34	1500	26.76	4000	24.42	6500	22.28	9000	20.32	11500
28.80	2000	26.28	4500	23.97	7000	21.87	9500	19.95	12000
								14.883	20000



No. 45–100

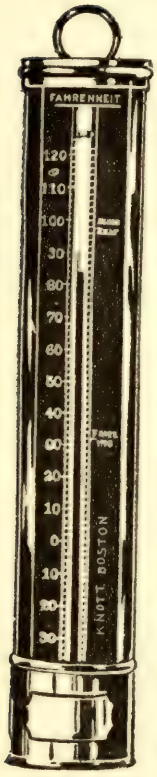
45–100 RECORDING BAROMETER (BAROGRAPH). Barographs are instruments arranged to record upon a chart all atmospheric changes in pressure, the amount of rise and fall of same, and the time such changes occurred. The mechanism of the ordinary barograph consists of a " pile " or series of vacuum chambers each secured to the other above and below, making a greatly magnified sensitive movement. This movement is further magnified and transmitted to an aluminum recording arm carrying a pen by a series of connecting levers. This pen records the changes in pressure on a chart which encircles a drum containing a clock movement. As this clock revolves once in seven days, a week's record can be obtained on the chart. As the top of the chart is divided into seven spaces, each allotted for one day a week and sub-divided to spaces representing two hours, it is possible to tell at what time of any day the atmospheric pressure underwent a change. This week's record will be in the form of a tracing along the chart. By referring to the top of the chart it may be noted at what day and hour a rise or fall of pressure occurred.

A Barograph, then, is the most reliable form of a barometer and has the further feature that observations are recorded, whereas in weather prognostications a single observation of the barometer is of little or no value. Thus, if a careful study of weather is made a reliable recording barometer (barograph) is absolutely necessary.

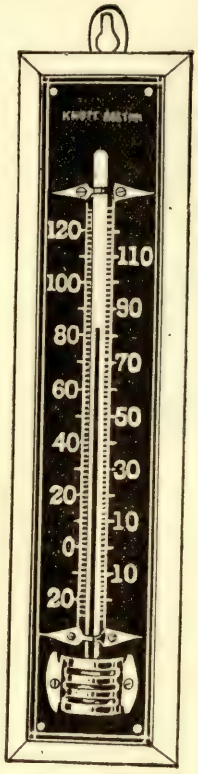
The instrument listed above has for years been the standard of Meteorological work, and its quality in all particulars is unquestioned. In addition to a careful and accurate fitting and adjusting of parts this instrument is handsome in appearance and will be found exceedingly valuable in any laboratory. Enclosed in mahogany frame glass case cover.

Complete with one year's supply of charts . . . . . Duty Free **$30.00**

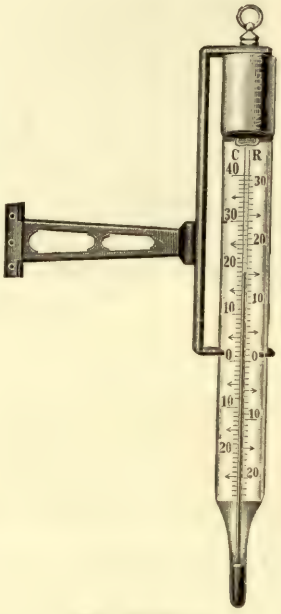
45–102 BAROGRAPH CHARTS as used in above instrument. Box containing one year's supply **2.00**



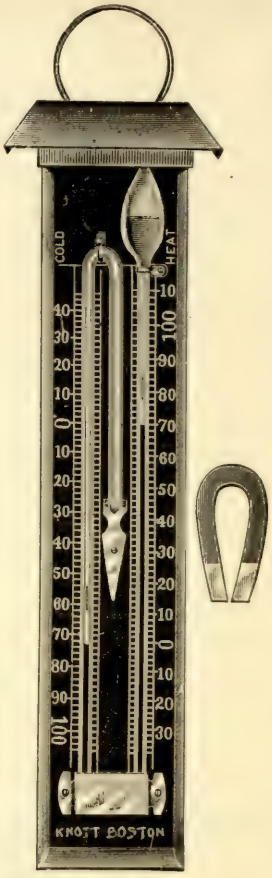
No. 63–10



No. 63–12



No. 46–25



No. 46–35

No. 46–30

63–10 **HOUSEHOLD THERMOMETER,** 8 inches long, heavy metal frame, black metal scale with white figures, reading from –30 degrees to 120 degrees Fahrenheit **$0.55**

63–12 **HOUSEHOLD THERMOMETER,** 10 inches long, metal scale on hardwood back, reading from –30 degrees to 120 degrees Fahrenheit . . . . . **.85**

46–25 **WEATHER BUREAU STATION THERMOMETER WITH CERTIFICATE,** milk glass scale sealed in glass cylindrical tube 30 millimeters diameter, length 45 centimeters. Range 30° below zero to 50°C. above with corresponding Fahrenheit scale, divisions to one-fifth degree, with certificate of accuracy.

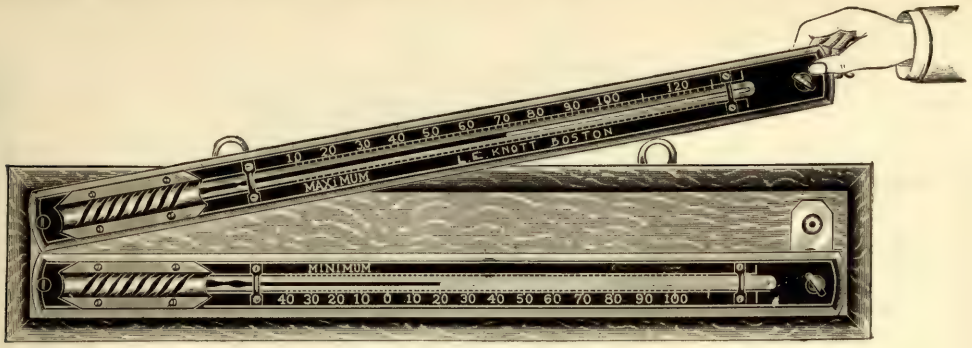
Complete with weatherproof holders for attachment to window frame . . . . . Duty Free **11.50**

46–30 **WEATHER BUREAU PATTERN THERMOMETER WITH CERTIFICATE,** engraved stem, magnifying mercury tube, cylindrical bulb, porcelain strip at side of tube in which are marked the figures and every fifth degree line of the scale, oxidized black plate, insulating brass support with binding screws. Scale range 40° below zero to 120°F. above **5.25**

46–35 **SIX'S MAXIMUM AND MINIMUM SELF-REGISTERING THERMOMETER,** black oxidized brass scales, white filled figures, japanned tin case, length 8 inches, scale range 10 to 40° below zero to 120°F. above. Enclosed in box **3.45**

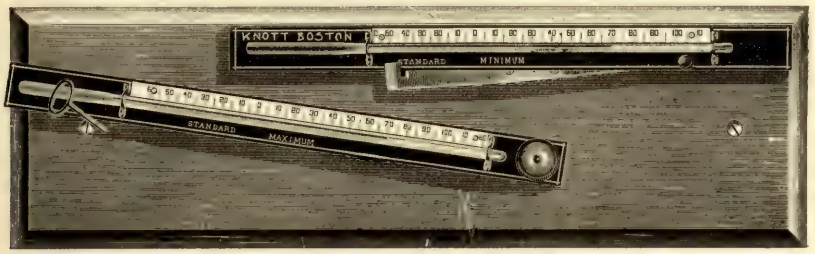
THERMOMETRIC CONVERSION FACTORS

F = 9/5 C+32	F = 9/4 R+32
C = 5/9 (F–32)	C = 5/4 R
R = 4/9 (F–32)	R = 4/5 C



No. 46–40

46–40 **MAXIMUM AND MINIMUM THERMOMETERS,** medium grade thermometers with magnifying tubes and black oxidized brass scales, each tube 10 inches long, mounted on a separate plate attached at one end with a thumb screw to the oak back so that the thermometers may be re-set as illustrated above **$3.90**

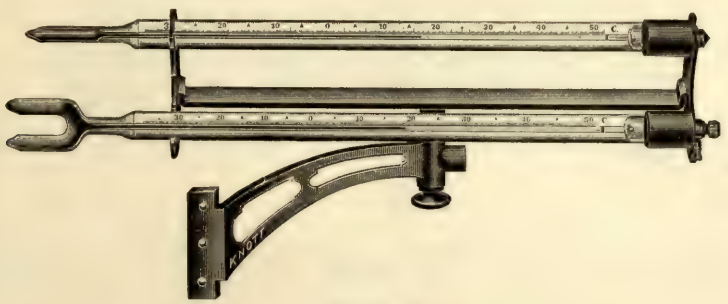


No. 46–50

46–50 **WEATHER BUREAU MAXIMUM SELF-REGISTERING THERMOMETER,** scale range 40° below zero to 120°F. above.
This thermometer has an engraved stem, magnifying tube, cylindrical bulb, porcelain strip at side of tube on which are marked the figures and every fifth degree line of the scale. It is mounted on an oxidized brass plate with insulating brass support with binding screws. . Each thermometer is 12 inches long and is furnished with a certificate of accuracy.
Enclosed in box **$6.35**

46–51 ——, same as above with magnifying spirit tube, range 20 to 60° below zero to 120°F above. Each thermometer is 12 inches long and is furnished with a certificate of accuracy.
Enclosed in box **5.85**

46–52 **WEATHER BUREAU MAXIMUM AND MINIMUM SELF-REGISTERING SET.** This outfit consists of the Maximum and Minimum Thermometers above appropriately mounted on a polished mahogany board 17 inches long by 5 inches wide. Each thermometer is furnished with a certificate of accuracy.
The whole, enclosed in a neat box **12.00**



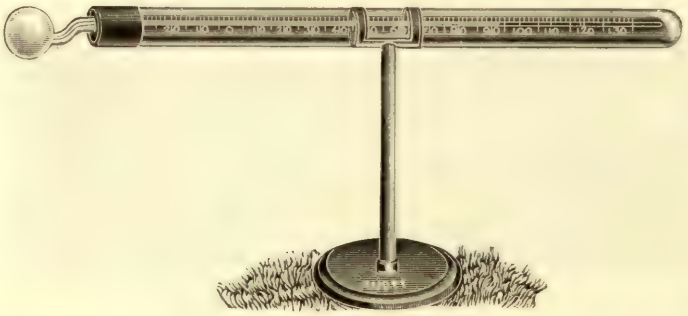
No. 46–60

46–60 **NORMAL MAXIMUM AND MINIMUM THERMOMETER with WINDOW HOLDER.** Milk glass scale sealed within cylindrical glass tube about 35 centimeters long accurately graduated to ⅕ degree from –30 to 50° Centigrade; with certificate of accuracy etched on back of each.
Mounted as illustrated on holder for attaching to window frame . . . . . Duty Free **$16.25**

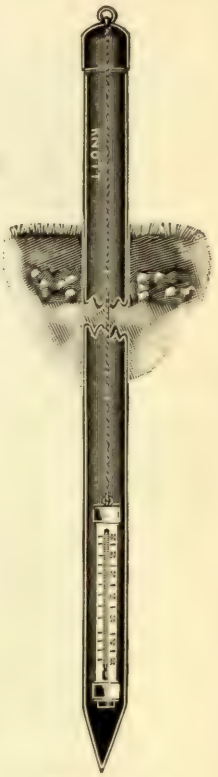
No. 46–70

46–70 **SOIL THERMOMETER,** 16-inch wood frame with handle, brass pointed ferrule, glass cylinder, hand written paper scale **$1.25**

46–75 **TWO-FOOT PRECISION SOIL THERMOMETER,** engine divided, attached to a brass chain suspended from a copper cap and then let down into the iron tube which is placed in the ground with 6-inch projection. Twenty-four inches long for a depth of eighteen inches . . . . . Duty Free **9.80**

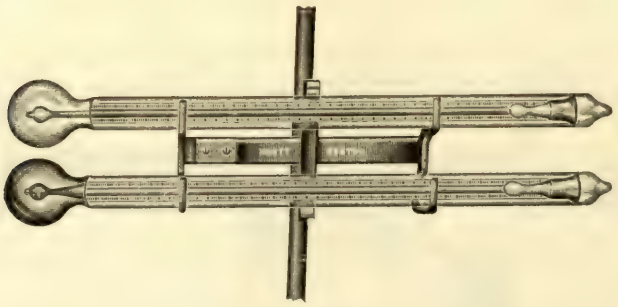


No. 46–80



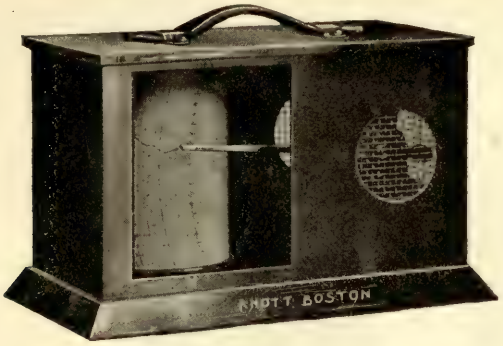
No. 46–75

46–80 **TERRESTIAL RADIATION MINIMUM THERMOMETER** divided and figured on stem and enclosed in a glass shield to protect divisions; extra sensitive bulb, mounted as illustrated Duty Free **$13.25**



No. 46–85

46–85 **ACTINOMETER,** after Arago-Davy, consisting of two similar maximum thermometers about 35 centimeters long, one with blackened bulb, the other bulb clear, each sealed in an insulating tube and both mounted in metal frame as illustrated . . . . . Duty Free **$27.40**



No. 46–110

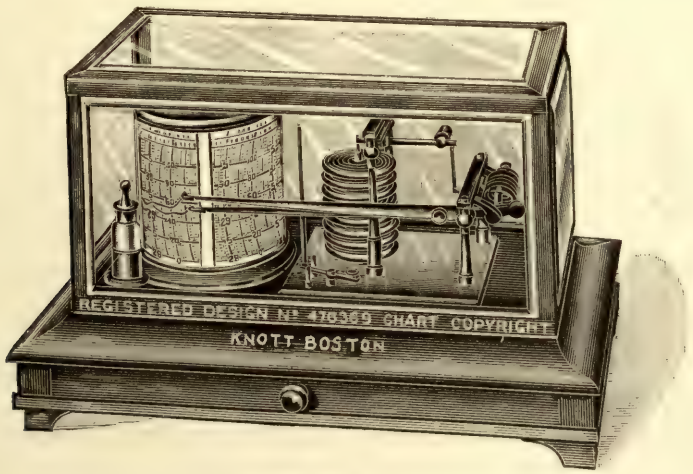
46–110 RECORDING THERMOMETER (THERMOGRAPH). What has been said of the advantages of the use of a barograph may just as consistently be repeated regarding the advantages of the use of the thermograph. The continuous record of temperature changes is necessary in any intensive study of Meteorology.

Our line of Thermographs consists of bi-metallic lamina arranged in such a manner that there are no levers other than the pen arm used in its construction. This construction insures rigidity, overcoming all lag or creep and friction, and in consequence is much more sensitive to slight changes in temperature than the standard mercurial thermometer.

This instrument is an 8-day cylinder clock, low drum type, chart showing range from 30° below to 110° F. above. Movement enclosed in a hinged metal case with padlock. This case is supplied with glass window, well ventilated, and with leather handle for carrying.

Complete with one year's supply of charts . . . . . Duty Free **$30.00**

46–112 THERMOGRAPH CHARTS, as used in above instrument. Box containing one year's supply . . **2.35**

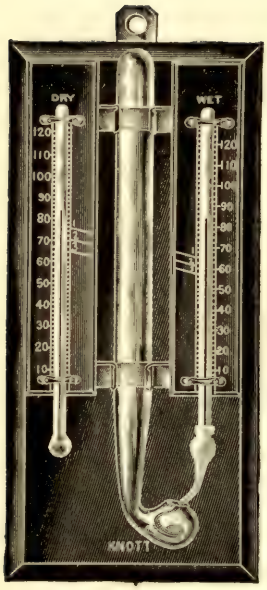


No. 46–120

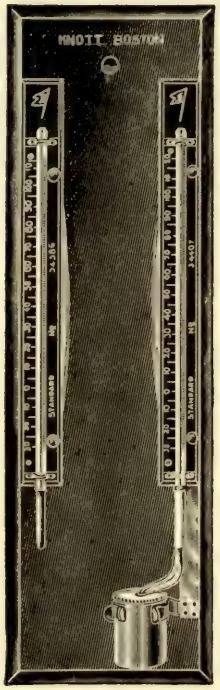
46–120 BARO-THERMO RECORDER (COMBINED THERMOGRAPH AND BAROGRAPH). The above illustration pictures a recent improvement which has been introduced into recording instruments by combining the Barograph and the Thermograph in the same instrument. The records are given on the same chart but in different colored inks to prevent confusion (blue for the Barograph and green for the Thermograph).

Baro-Thermo Recorder . . . . . Duty Free **$50.00**

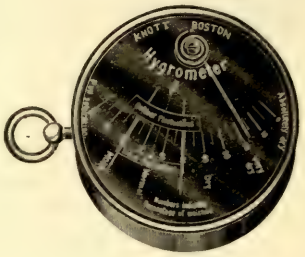
46–122 BARO-THERMO RECORDER CHARTS, one year's supply, for use with above **2.50**



No. 47–15



No. 47–20



No. 47–25

47–10 **"SLING" PSYCHROMETER OR HYGROMETER** for obtaining quick and more accurate results than are possible with the stationary wet and dry bulb instruments.

This instrument consists of two accurate thermometers firmly attached to a metal arm swiveled to a wood handle. In use one of these bulbs is covered with a wicking which should be thoroughly saturated with water. To obtain readings, whirl the instrument fifteen or twenty seconds, holding it well away from the body. Stop and note the wet bulb temperature; continue the operation, whirling and reading until two readings of the wet bulb thermometer are obtained alike or nearly so. This will be the lowest temperature. Tables and full directions are supplied with the instrument to determine the per cent of relative humidity . . . . . Each **$2.50**

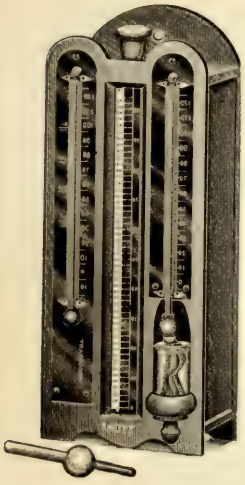
47–15 **MASON'S HYGROMETER** (Wet and Dry Bulb), good quality, magnifying mercury tube, silvered brass scales with black filled figures and graduations, mounted on polished oak board 11 × 5 inches. Enclosed in a box **3.35**

47–20 **WEATHER BUREAU PATTERN HYGROMETER** (Wet and Dry Bulb), consisting of two No. **46–30** Standard Thermometers mounted on a polished mahogany board 17 × 5 inches with nickel-plated brass cistern and silk wick.

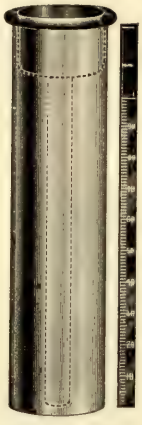
This instrument is the United States Standard and may be depended upon for the utmost accuracy. Each thermometer is supplied with a certificate of correction. Enclosed in box **11.80**

47–25 **SPIRAL HYGROMETER,** 80 millimeters diameter.

This simple little instrument, with handsomely nickeled case, is provided with a scale denoting the humidity of the air without reference to tables **2.00**



No. 47–40



No. 47–65

No. 47–75

47–40 HYGROPHANT, a simple, convenient, and efficient means of determining both the temperature and humidity of the air with accuracy and without computation.

This instrument is provided with two standard thermometers, one showing the temperature of the air, the other the temperature due to evaporation. A cylinder upon which is inscribed a series of columns of figures numbered at their headings from 1 to 22 may be noted between the thermometers. These strips represent the difference in degrees between the indications of the thermometers and the columns exhibiting relative humidity or percentage of moisture in the air for every degree of temperature indicated by the thermometer. A fixed scale upon the casing in which the cylinder revolves indicates the relative humidity or percentage of moisture in the air.

In use the cup is filled with pure water into which dips the wicking attached to the wet bulb thermometer. As soon as this wicking and gauze which covers bulb become wet the instrument is ready for use. In ascertaining the actual temperature, read the indication of the thermometer on the right of the instrument; in ascertaining the temperature due to evaporation read the indications of the wet bulb thermometer. Now note the difference in number of degrees between the two thermometers. Turn the cylinder by means of the knob on the top so as to present to view the column of figures having at its head the number corresponding to this difference. In line then with the division on the fixed scale which corresponds to the degree indicated by the wet bulb thermometer, may be read the relative humidity or percentage of moisture in the air.

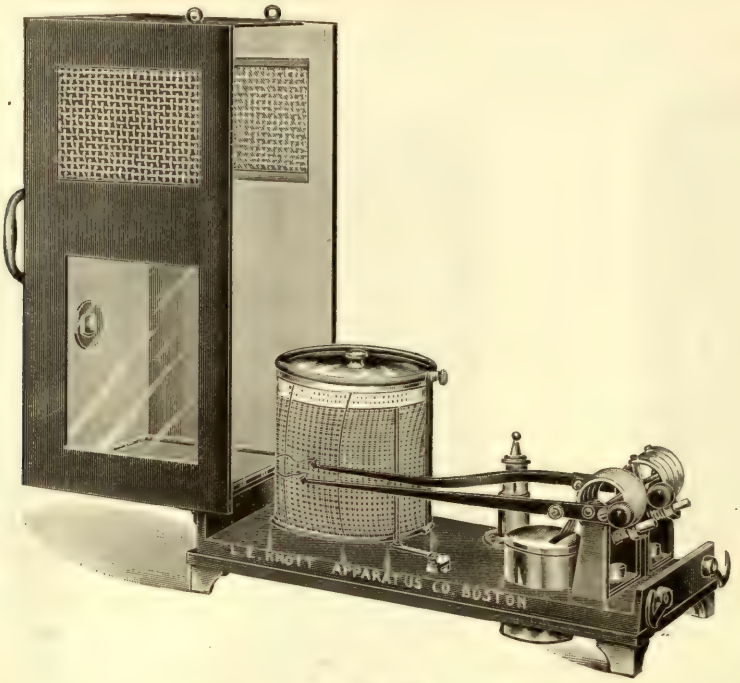
Complete with full and explicit directions for use **$12.50**

47–65 RAIN GAUGE, United States Weather Bureau type, diameter 3 inches, height 13 inches, with overflow and measuring stick **2.75**

47–75 REGISTERING RAIN GAUGE. The rain gauge illustrated above is a pattern which is known as the " tilting bucket " gauge. No measurement is necessary as the rain is collected in the 8-inch receiver and is taken through a small pipe and dropped into one side of a bucket. When a given amount of rain has collected in the bucket (0.01 inch) the weight of the rain on the laden side causes it to over-balance, and by a mechanical arrangement the hand moves 0.01 inch at each operation.

The rain still passing through the receiver is collected in the opposite bucket. When that has received the given amount the same operation is repeated. The great advantage of this type of gauge is that it is zero set and is particularly useful when a person wants to keep a record of rainfall by the month or week. The dial registers one inch by 0.01 inch, the second or smaller dial reads upwards of 12 inches.

Enclosed in metal case 10 × 8 inches . . . . . Duty Free **24.75**



No. 47–100

47–100 SELF-RECORDING HYGROMETER (HYGROGRAPH) for accurately recording on a revolving chart the daily and weekly variations and differences of temperature readings between the dry and wet bulb thermometers, and for readily ascertaining the proportions of aqueous vapor held in suspension by the atmosphere at any time and in any locality.

The vital portion of this instrument consists of two identically similar cylindrical spirals composed of narrow ribbons of specially and most carefully prepared metals of different coefficients of expansion and the combined action of which is highly sensitive, uniform, and true, throughout the whole range of the scale required, whether open or closed graduation. Each spiral is centered on its axis, one end of which is fixed to a support and fine adjustment, while the opposite end is free to move and convey its least motion to the arm which carries the pen charged with ink for tracing on the chart. One of these spirals is covered with a strip of specially selected absorbing cotton, the end of which dips in water contained in an appropriate copper vessel. Capillarity provides a constant supply of moisture to the evaporating surface of the bulb, and according as evaporation is rapid or slow the parallel curves traced on the chart will be wide apart or close together. Rapid evaporation causes the wet bulb to indicate a lower temperature than the dry one. Slow evaporation, on the other hand, allows the wet bulb to attain the temperature of the surrounding air which, being humid, also affects the dry bulb, consequently the difference between the two readings will vary from 1.5° to 2° — almost complete saturation.

This instrument is compact, substantially and accurately constructed, self-contained, enclosed in a neat metal case without any projections liable to injury, and provided with carrying handle.

As may be noted from the structure, this instrument may be used as a Thermograph as well as a Hygrograph.

Complete with Hygrometrical tables and one year's supply of charts, range 10° to 110°F. Duty Free **$58.00**

HUMIDITY TERMS

ABSOLUTE HUMIDITY is the amount of water vapor in the air, expressed in the number of grains per cubic foot of air.

RELATIVE HUMIDITY is the percentage of amount of water vapor in the air. Relative humidity depends chiefly on the temperature of the air. At saturation relative humidity will become 100 per cent.

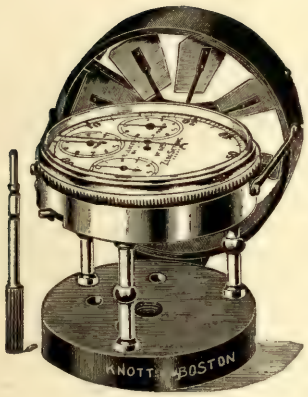
The **DEW POINT** is the temperature of the air at which its moisture begins to condense into visible water drops.

VELOCITY OF AIR

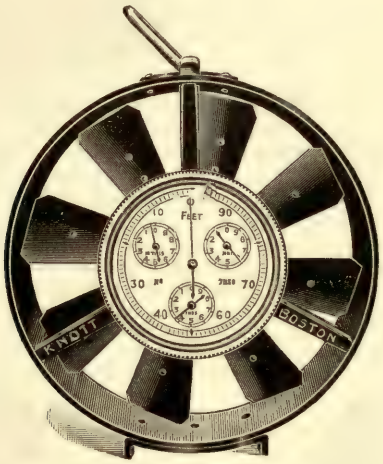
To determine the velocity of air in an opening it is necessary to take a number of readings in different positions. Determine the average and the result will be the average velocity in linear feet. Multiply the number of feet recorded by the area of the opening to obtain the number of cubic feet of air passing through the opening per unit of measured time.

FORCE OF AIR

To ascertain the force of the air current multiply the square of the velocity of the air in feet per second by .0023



No. 48–12



No. 48–17

48–10 **ANEMOMETER** for measuring air currents through tunnels, mines, ventilators of public buildings, etc. The indications are obtained by means of a delicately poised fan wheel, the recordings being started by the long hand which traverses the outer circumference of the main dial which indicates a passage of 100 feet of air. This recording is continued up to 10,000,000 feet by a series of smaller dials, six in number. The disconnector projecting from the band of the instrument opposite the fan wheel serves to throw the mechanism out of gear, arresting its action when required.

In use the instrument is placed in the current in a number of different positions. Take the number of feet that have passed during a certain time, for example one minute, divide the total by the number of readings and obtain the average. Multiply this average by the square of the opening and the result is the velocity of air in feet passing in a given time.

Each instrument is enclosed with zero setting attachment in a neat mahogany case . . . . Duty Free **$19.25**

48–12 ——, same as above, but with four dials reading to 100,000 feet. This instrument is recommended in preference to above in that the parts are not so delicate . . . . . Duty Free **19.25**

48–15 **BIRAM'S ANEMOMETER,** for similar use as No. **48–10.** In this type of instrument the revolutions are recorded on a dial in the center of the instrument. Each instrument is tested and furnished with a chart of corrections, supplied with patent zero setting attachment in neat mahogany box, diameter 3 inches, two dials reading to 1,000 feet. This instrument will stand a pressure of 1,000 feet per minute . . . . . Duty Free **16.25**

48–17 ——, similar to above, 4 inches in diameter with four dials reading to 100,000 feet; will stand pressure of 3,000 feet per minute . . . . . Duty Free **17.40**

No. 48–22

48–20 BIRAM'S HIGH SPEED POCKET ANEMOMETER, capable of registering to very strong blast currents, withstanding a blast up to 8,000 feet per minute. This anemometer is supplied with disconnector and zero setting attachment. It is a four-dial instrument registering up to 200,000 feet. Each instrument is tested to its maximum capacity and a chart of corrections supplied. The instrument is furnished in leather case . . . . . Duty Free **$32.25**

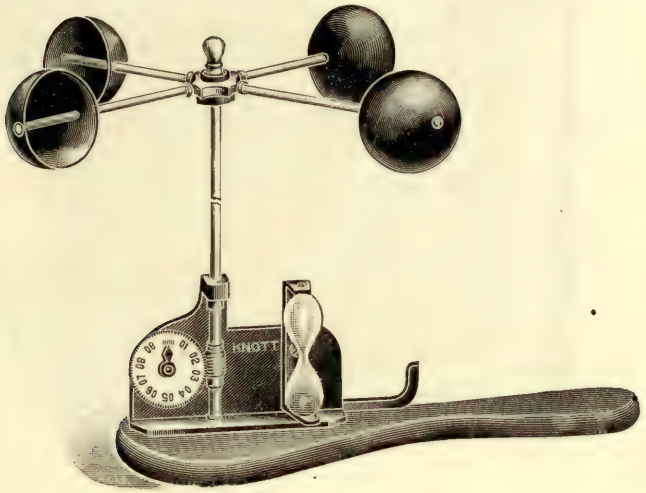
48–22 BIRAM'S POCKET ANEMOMETER, This anemometer is similar in design to Nos. **48–15** and **48–17,** but of somewhat more rigid construction, with altered type of case. This type has hinged lids of heavier metal and the dial is absolutely enclosed insuring perfect safety in all positions. Diameter 2 inches; thickness ¾ inch; weight 5½ ounces. Two dials reading to 1,000 feet; will stand a pressure of 1,000 feet per minute . . . . . Duty Free **28.50**

No. 48–30

48–30 REGISTERING ANEMOMETER. This simple device for indicating the velocity of the wind in miles consists of a vertical shaft, to the upper end of which are fastened four arms, each carrying a Robinson hemispherical copper cup. These cups turn in one direction, regardless of the direction of the wind, and at a ratio determined by experiment. To the lower end of the shaft is fastened an endless screw which, as the shaft revolves, actuates a wheel which in turn meshes into a series of other wheels; thus the miles are indicated on the registering dial. The dial is so arranged as to show velocities from one-tenth of a mile to 10,000 miles, and then it repeats, commencing at zero.

To ascertain the rate in miles per hour at which the wind is traveling, make two readings with an interval of ten minutes and multiply the difference by six.

This instrument is carefully made and requires but little attention. All parts are interchangeable **$22.00**



No. 48–35

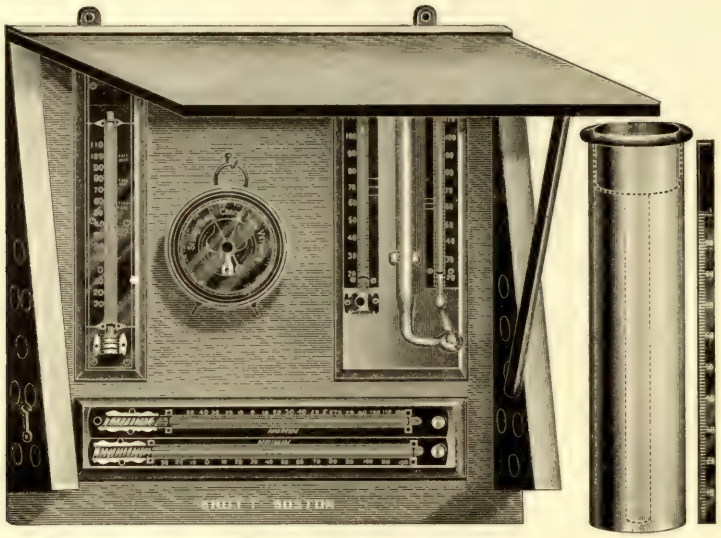
48–35 QUICK READING CUP ANEMOMETER OR WIND GAUGE with automatic minute glass.

This anemometer is supplied on a mahogany base with sand glass. It is provided with a dial registering to $\frac{1}{100}$th mile. The registering dial, having been set to zero, is thrown into gear with the revolving cups by a sliding action which at the same time reverses the sand glass. The number of revolutions, plus any fraction made by the dial during the time the sand takes to run out, multiplied by thirty, gives the velocity of wind in miles per hour.

This instrument is suitable for any velocity . . . . . Duty Free **$18.25**

STANDARD TABLE

DESCRIPTION	MILES per hour	FEET per Minute	FEET per Second	FORCE in lbs. per Square Foot	PRESSURE in lbs. per Square Foot
Scarce Perceptible . .	1	88	1.47	.005	.0049
Just Perceptible . . .	2	176	2.93	.020	.0195
	3	264	4.4	.044	.0460
Gentle Breeze	4	352	5.87	.079	.0807
	5	440	7.33	.123	.1251
Pleasant Breeze . . .	10	880	14.67	.492	.4957
	15	1,320	22.0	1.107	1.1184
Brisk Gale	20	1,760	29.3	1.968	2.0095
	25	2,200	36.6	3.075	3.1153
High Wind	30	2,640	44.0	4.428	4.6618
	35	3,080	51.3	6.027	6.0700
Very High Wind . . .	40	3,520	58.6	7.872	7.9195
	45	3,960	66.0	9.963	9.9875
Storm	50	4,400	73.3	12.300	12.3802
Great Storm	60	5,280	88.0	17.712	17.8189
	70	6,160	102.7	24.108	24.2594
Hurricane	80	7,040	117.3	31.488	31.6700
	100	8,800	146.6	49.200	49.4854



No. 48–100

48–100 HARCOURT STUDENTS' METEOROLOGICAL EQUIPMENT. This is a complete set of Meteorological instruments of standard quality suitable for all work. The set must not be confused with various types on the market inasmuch as our set comprises standard instruments of medium quality. The set consists of the following, — one 10-inch Thermometer, metal scale on hardwood back; one 10-inch Maximum and Minimum Thermometer, mounted on hardwood back; one Mason's Hygrometer, mounted on polished oak board 11 × 5 inches; one 4-inch Aneroid Barometer, open dial, graduations both English and Metric systems, and one 3-inch U. S. Weather Bureau Rain Gauge with Measuring Stick.

The various instruments cited above, with the exception of the Rain Gauge, may be mounted within the Instrument Shelter as illustrated. This Instrument Shelter is of substantial structure, painted inside and out with a durable coat of lead paint. It is provided with brackets for attachment to wall.

Instrument Shelter complete as illustrated with all instruments, including Rain Gauge **$15.25**

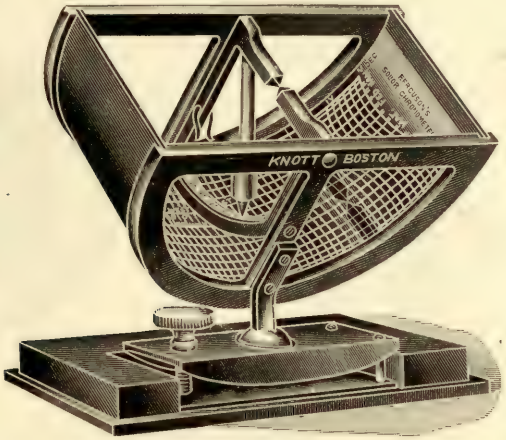
48–102 ——, as above illustrated, but without Rain Gauge **12.50**

INSTRUMENT SHELTER

48–115 INSTRUMENT SHELTER. Meteorology and climatology study in our schools has so come to the front during the last few years that it has become almost essential that a shelter for recording instruments be provided for outside use.

Our instrument is constructed after the latest pattern Weather Bureau Instrument Shelter and may be mounted on legs for use on the school grounds or attached to the side of a wall. It is sufficiently large to hold easily both a Barograph and Thermograph, a Hygrometer and a set of Maximum and Minimum Thermometers, an Aneroid Barometer and a Thermometer. It is constructed of the best quality straight-grained pine with swing door provided with lock and key. We secure perfect circulation of air and obstruction to rain by means of the blind construction usually employed in the manufacture of shelters. It is painted oustide and in with a durable coat of lead paint.

Instrument Shelter, complete ready for mounting, but without instruments of any kind **$20.00**



No. 49–10

49–10 SOLAR CHRONOMETER. This instrument is a simple contrivance by means of which timepieces in out-of-the-way places can be regulated to correct time without the necessity of making any calculations or allowance for equation of time. By means of features in this instrument the trouble of setting up level and orienting is entirely obviated. This instrument is thoroughly practical and of great service, especially where there are no clocks. It is simple to use and reliable to within one or two minutes of time. It is portable and can be used in any position where the sun is shining, even inside a closed window, and does not require a smooth surface.

It is self-orienting, that is, it can be used in any meridian by its own indications without the aid of a magnetic compass or known time. It gives " mean time " by direct readings without any calculations or allowance for equation of time. It can be set to show local " mean time " or any standard time.

The apparatus consists of a rectangular frame attached to a curved metal plate carrying a reversible dial which is marked on both faces with curved hour lines and straight day lines. Each face contains space for six months.

A polar axis projects a shadow point on the dial and indicates time with great accuracy. Latitude is indicated on a graduated arc by a suspended pointer. The instrument is attached to its base by a ball and socket fitting permitting adjustments in all directions. Diameter 6¼ inches.

Complete adapted for use in any latitude with full and explicit directions for care and use. Duty Free **$37.50**

49–15 SOLAR COMPASS ATTACHMENT for use with above Chronometer, converting it into a very accurate solar compass which will give a " true meridian " line within one degree of accuracy, unaffected by magnetic or local attraction. At the same time it does not interfere with the use of the instrument as a Chronometer. This attachment will be found of great service in localities where magnetic attractions render a compass unreliable, and also for very fine readings of a compass and for ascertaining the magnetic variations . . . . . Duty Free **12.50**

No. 49–25

No. 49–27

49–25 SUN DIAL AND COMPASS. This little instrument, 2 inches in diameter, combines features of both compass and sun dial. It is a pocket compass with raised dial with distinct divisions and figures and agate center needle. As a sun dial it is provided with distinct hour lines and may be readily set to any latitude. Case is nickel-plated and provided with hinged cover . . . . . Duty Free **$6.75**

49–27 MINER'S COMPASS AND DIPPING NEEDLE. In this instrument the magnetic needle is horizontally balanced on an axis within a graduated circle and in which the needle will be found to assume a position inclined to the horizon. The inclination of the needle as read off on the graduated scale will show the dip. If the compass is held horizontally, it serves as an ordinary compass. This instrument is handsomely finished in polished and lacquered brass, raised silvered metal graduated scale, diameter 3½ inches. It is provided with a brass cap cover and is enclosed in a neat plush-lined hinged box **11.00**

No. 17–200

17–200 UNIVERSAL SUN DIAL. In our sun dial, which may be adapted to any latitude, we offer an instrument scientific in design and capable of accurate work. It is 12 inches square, substantially constructed of metal, and can be continuously exposed without injury in any climate. By an ingenious arrangement not illustrated a correct setting for any latitude can easily be obtained.

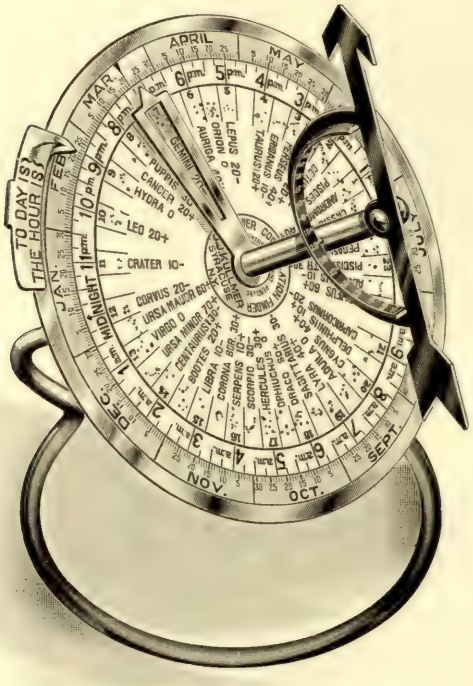
We supply with each instrument a printed form on which correction curve for any latitude can easily be plotted from the full and explicit directions furnished with each instrument. This instrument is durably finished with a protective coating, the figures and lines showing in colors against the black finish of the casting.

Universal Sun Dial complete with directions for correct setting for any latitude, directions for plotting correction curve, and printed form for same **$7.50**

No. 49–30

49–30 SUNSHINE RECORDER after Campbell-Stokes, for making records of the duration of bright sunshine. This recorder is one of the so-called " burning " recorder types. In this type the belt is divided into three zones, each zone being constructed to receive a strip of card which, following the curve, may be taken to reduce the respective zone or spherical surface. In front of this belt is a ground and polished crystal sphere which acts as a lens or burning glass and scorches a trace showing the duration of bright sunshine upon these strips of card. This apparatus is provided with a divided arc which enables the purchaser to set the instrument to the proper latitude for accurate records. The parts are carefully made and neatly finished. Illustration is about ⅓ size. Duty Free **$55.00**

49–31 PAPER STRIPS for use in above Sunshine Recorder. Box containing a year's supply. . Duty Free **5.75**



No. 49–100

49–100 KULLMER STAR CHART. This new astronomical instrument is based on the principle of the equatorial telescope mounting, — an arrow taking the place of the telescope. It is so simple and ingenious that it is fascinating to operate. In the cut the instrument is set for February 22, at 9 P.M. Place the arrow wherever you wish and it will be pointing, when properly set, at the star-group shown and named in the opening of the indicator below. No knowledge of astronomy is necessary to operate it, and the pupil soon gains a correct conception of the general plan of the heavens.

SOME OF THE THINGS IT TEACHES

First and foremost, it not only illustrates but forces on the attention of the pupil what the average educated man rarely learns — the apparent daily rotation of the whole sky. The use of this instrument in higher geography will positively overcome this glaring defect in our school training.

It marks out on the sky the actual path taken by stars, sun, moon, and planets, — and shows where they rise and set.

It teaches the seasons more clearly than the customary method of projecting the pupil into space; it shows how the sun moves north and south on the sky and marks its path at the solstices and equinoxes, thus showing an angle of the sun's rays and the length of the day.

It gives a perfect demonstration of why we always see the North Star in its place, and why the Dipper is always seen; it explains clearly " winter stars " and " summer stars."

For astronomy courses it forms a complete student observatory. The instrument is a combination of an equatorial telescope, a slide-rule for sidereal time and star maps just where they are needed.

The pupils can actually learn the constellations — it points right at them.

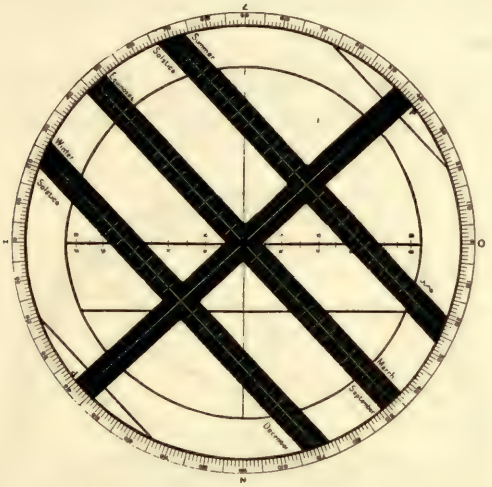
Prominent astronomers have proclaimed it the simplest device for learning sidereal and solar time. The sidereal time is read off directly.

Right Ascension and Declination give no trouble at all; the red figures on the dial are Right Ascension, and the plus and minus figures are Declination.

The instrument in its leatherette case with the star maps can be loaned to pupils for solving set exercises, such as plotting moon and planet orbits, taking right ascension and declination of set objects.

The instrument is made of nickeled metal with celluloid dial and cannot be easily soiled or broken.

With booklet " Star Maps and Star Facts," in neat case **$5.00**



No. 49–110

49–110 SEASONAL TWILIGHT CHART, designed and copyrighted 1907 by Miss E. Rebecca Ellis of the Department of Physical Astronomy at Wellesley College, for simplifying the teaching and explaining in full the phenomena of the seasons, changes in the lengths of days and nights, etc.

This chart is the orthographic projection of a globe upon a plane from a due east point in the plane of the horizon. The chart is 12 × 12 inches, divisions and figures distinct and legible and the size ample for use to advantage from the lecture table. The student, however, will gain a much clearer grasp of the whole subject if he works out the various problems with the chart in hand. The chart shows:

1. The comparative lengths of day, night and twilight at any place at different seasons of the year.
2. The comparative lengths of day, night and twilight at different places at the same season of the year.
3. The absolute lengths of day, night and twilight at any place at any season.
4. The time of sunrise and sunset at any place at any season.
5. The azimuth of sunrise and sunset points at any place at any season.
6. The noon elevation of the sun at any place at any season.
7. The midnight depression of the sun at any place at any season.
8. The phenomena of the midnight sun.
9. The diurnal path of the sun at the poles (6 months day and 6 months night).
10. The diurnal path of the sun at the equator (days and nights equal; and extremely short twilight).

Explicit and full directions in pamphlet form have been prepared by the designer. This pamphlet is sent gratis with each chart . . . . . Each Chart **$1.00**

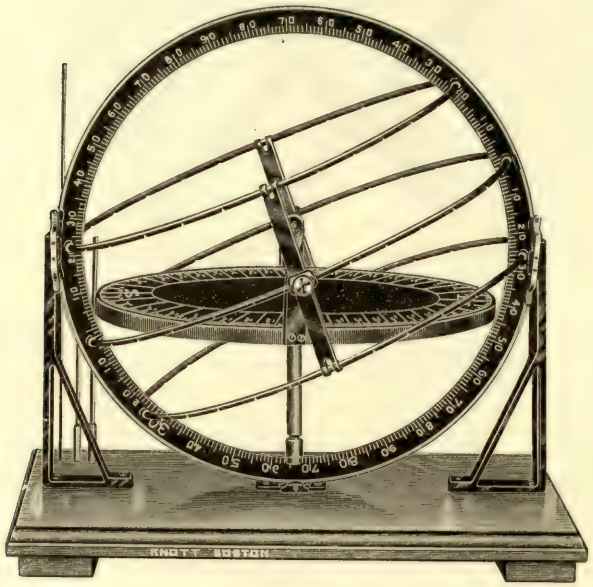
Per Dozen **9.00**

No. 49-120

THE B-K SOLAR CALCULATOR

Invented by FRANK L. BRYANT

ERASMUS HALL HIGH SCHOOL, BROOKLYN, N. Y.



No. 49–120

The object of this ingenious instrument is to provide a simple apparatus for teaching the fundamental ideas of the apparent motion of the sun in relation to any point on the earth's surface and at any time of the year. It is especially designed for the use of students in the laboratory for working out certain problems which will be noted below. It is also of value to the teacher in lecture work for all grades of geography instruction from the grammar school to advanced work in the college.

This instrument, about 16 inches high and 16 inches wide, is especially adapted for the lecture table, although it was primarily designed for individual student use. A special feature in connection with the use of the instrument and one entirely new, is that the horizon disc may be lowered and adjusted for plotting shadow curves at the time of the solstices and equinoxes for different latitudes. This work has been practically impossible before the introduction of the B–K Solar Calculator. Its value, therefore, will be especially appreciated by teachers of Physical Geography.

The following exercises may be performed by the use of the instrument:

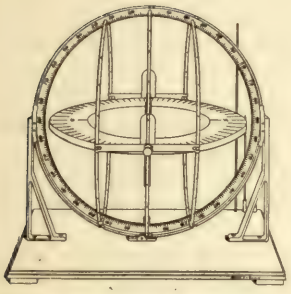
1. Find the time of sunrise and sunset at any latitude at any time of the year.
2. Determine the length of day at any latitude at any time of the year.
3. Find the relative distribution of insolation over the earth at different times of year.
4. Find the direction of sunrise and sunset at any latitude at any time of the year.
5. Find the altitude of the sun at any latitude at any time of the day or year.
6. Plot the curves of a shadow cast by an upright post at any latitude at the time of the solstices and equinoxes.
7. Interpretations of shadow curves.
8. Show relation of elevation of celestial pole to latitude.
9. Show relation of zenith distance of sun to latitude at different times of the year.
10. Show relation of length of twilight to latitude at different times of the year.

B-K SOLAR CALCULATOR, brass with oak base **$15.00**

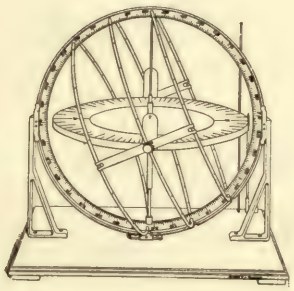
Directions for use furnished with each instrument. Special price in lots of ten

No. 49-120

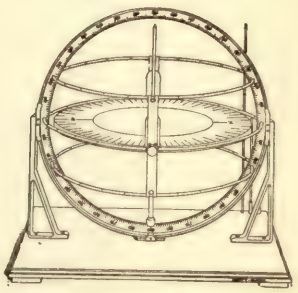
THE B-K SOLAR CALCULATOR



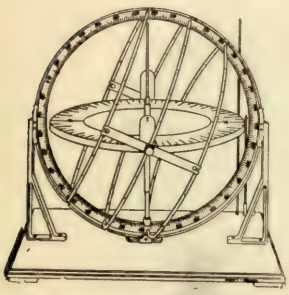
Set for the Equator



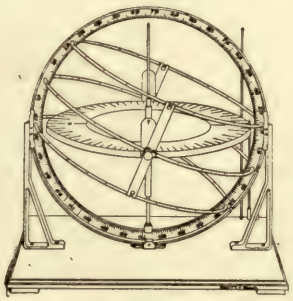
Set for Tropic of Cancer,
23½° N. Lat.



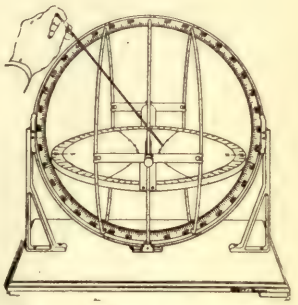
Set for the North Pole, 90°



Set for Tropic of Capricorn
23½° S. Lat.

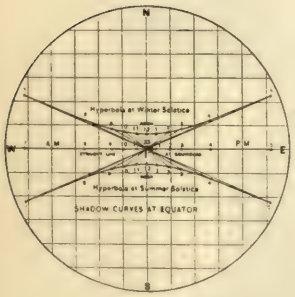


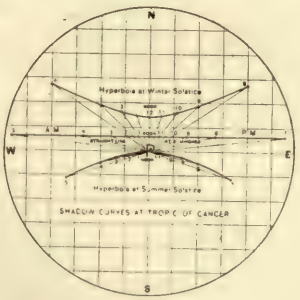
Set for the Arctic Circle,
66½° N. Lat.

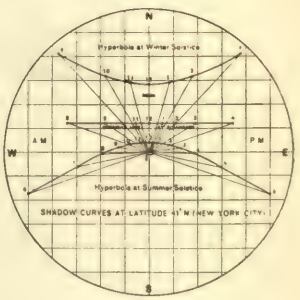


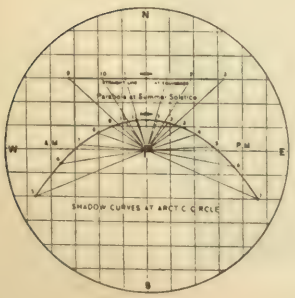
Set for plotting the Shadow
Curves at the Equator

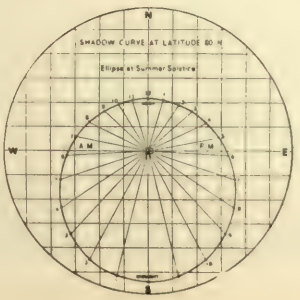
FORMS OF SHADOW CURVES

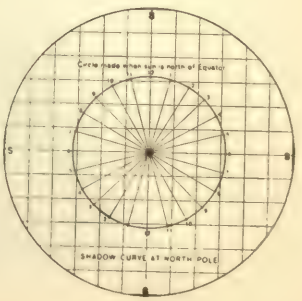












No. 49-175

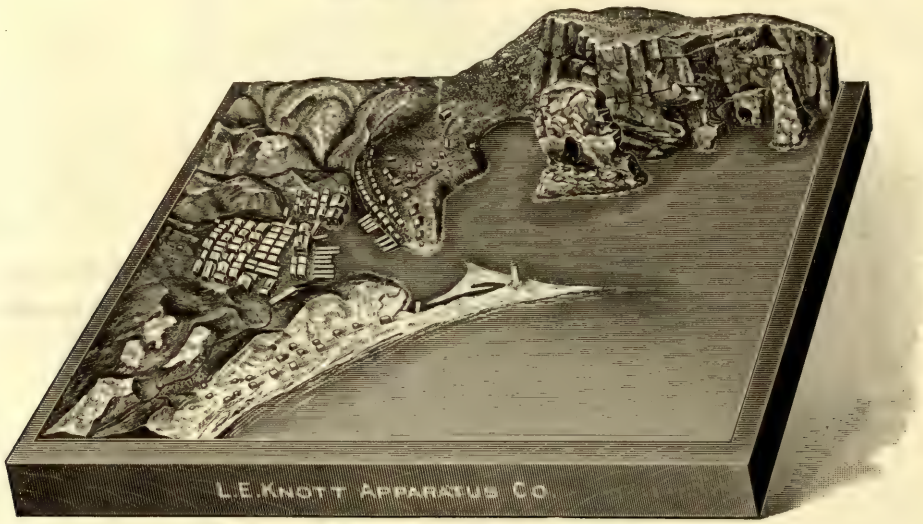
CURTIS NATURALISTIC MODELS

These models are true scale reliefs, 9 × 9 inches, representing the forms of the earth's surface, durably constructed of a special composition, beautifully colored to reproduce the color scheme of the natural object. They may be handled as readily as a school book and used wherever Geography is taught. They are especially adapted for work in connection with courses in Physical Geography. This wide range of service is due to the fact that each model is based on well selected types taken from actual occurrences in the field, and reproduced in very characteristic forms.

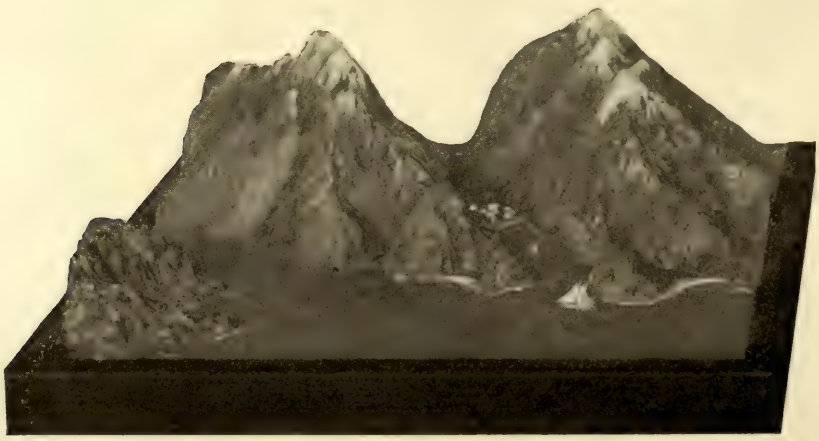
While it is true that the beginners will get but a small portion of what the advanced student may obtain, they will lose nothing by the completeness of the subject and what they do gain will come in the easiest way.

The set comprises six models, each enclosed in a book-cover case into which the models slide, permitting them to be handled and stored like books. The set consists of the following:

SEACOAST



No. I. SEASHORE BORDERING A PLAIN

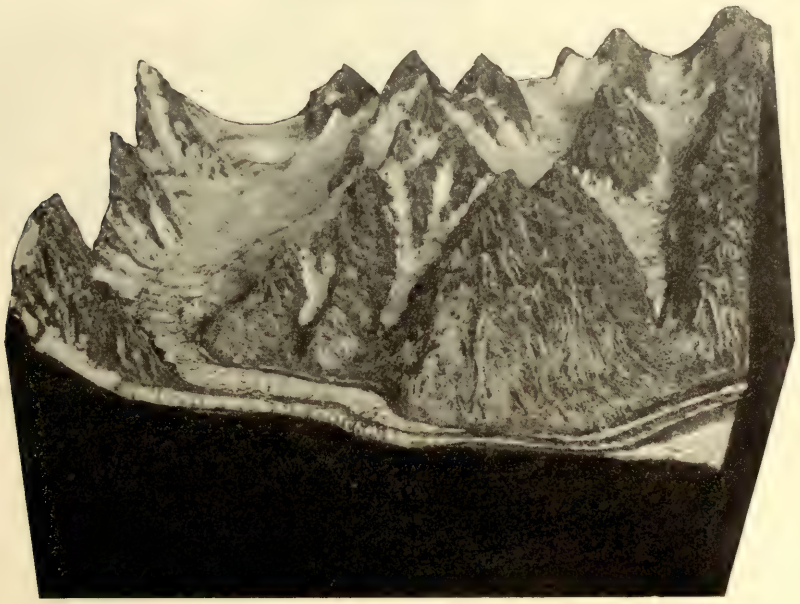


No. II. AN EMBAYED MOUNTAIN COAST

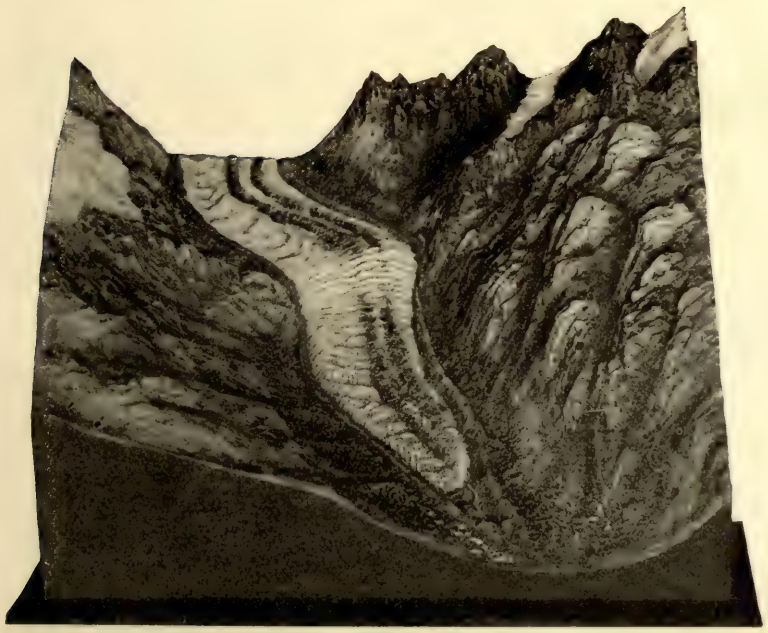
No. 49-175

CURTIS GEOGRAPHY MODELS

GLACIERS



No. I. HEAD OF A GLACIER

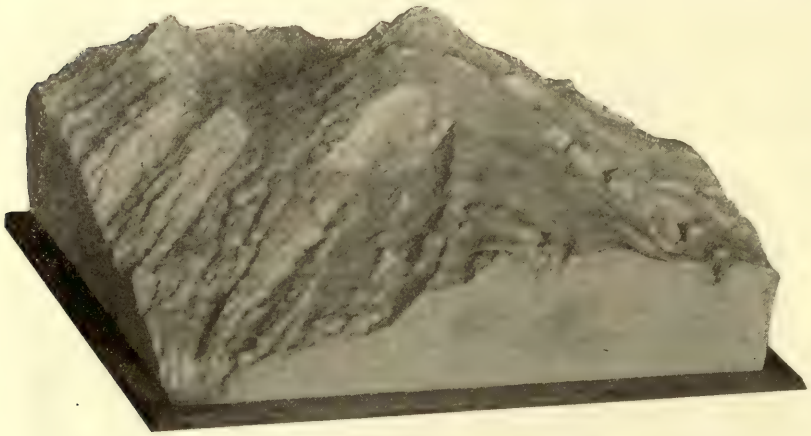


No. II. LOWER END OF A GLACIER

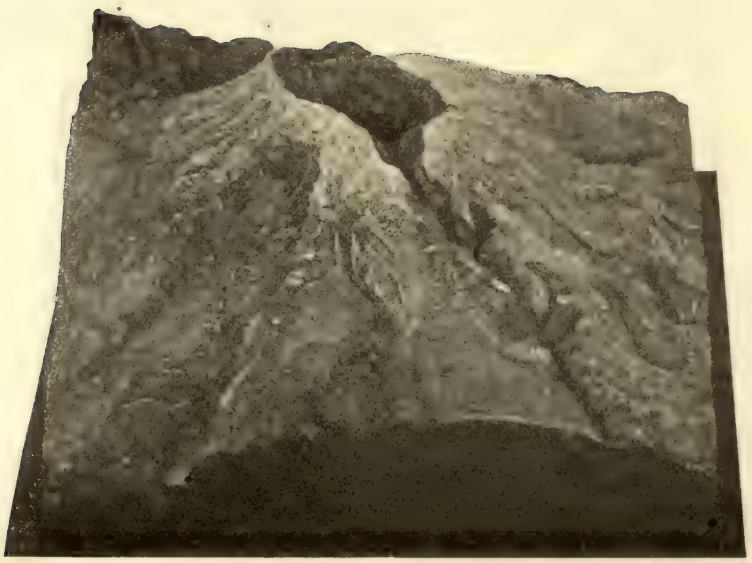
No. 49-175

CURTIS GEOGRAPHY MODELS

VOLCANOES



No. I. A FRAGMENTAL CONE
(VESUVIAN TYPE)



No. II. AN OPEN CRATER (CALDERA)

No. 49-175

CURTIS GEOGRAPHY MODELS

MANUAL
SEACOAST No I COASTAL PLAIN
SEACOAST No II MOUNTAIN COAST
VOLCANOES No I A CINDER CONE
VOLCANOES No II A CRATER
GLACIERS No I HEAD OF A GLACIER
GLACIERS No II FOOT OF A GLACIER

SET OF GEOGRAPHY MODELS IN COVERS

SEACOASTS

No. I. SEACOAST BORDERING A PLAIN.

A Plain which borders the sea.
Rivers which cut the plain and empty into the sea through an estuary.
A Harbor lying at the head of the bay at the mouth of the largest stream and on its shores.
A Seaport Town situated on the bay. Vessels may lie at the wharves, load and discharge cargoes well sheltered from storms.

No. II. EMBAYED MOUNTAIN COAST.

A Bay reaching up into the mountainous land.
Mountain Peaks which rise abruptly from the sea.
A Narrow Valley flanked by steep mountain sides.
A River flowing through the valley.
A Delta at mouth of the river and head of the bay.

VOLCANOES

No. I. FRAGMENTAL CONE (VESUVIAN TYPE).

A Young Volcanic Mountain rising from the sea.
An Active Volcano at top of mountain; hot stones, ashes, lavas running down the sides of the mountain.
Lava " Flows " showing as hardened rock.
An Old Volcanic Mountain.

No. II. AN OPEN CRATER (CALDERA).

The Top of a Volcano, showing devastated region about the summit.
A Deep Crater Pit, a " Caldera."
An Old Crater partially filled with lava.
Fresh Lava.

GLACIERS

No. I. HEAD OF A GLACIER.

Mountain Peaks, sharp topped ridges.
Lofty Valleys, partially filled with snow and ice, descending steeply.
Snow Fields, masses of loose and compact snow which feed the Rivers of Ice.
Glaciers.

No. II. LOWER END OF A GLACIER.

The Foot of a Glacier.
The Head of a River, the melting glacier giving rise to a river.
An Open Valley.
An Alpine Village, low huts clustering near the foot of the glacier.

Complete set of six models, each in Book Cover Case, appropriately labeled, including a descriptive manual, a complete text on the subjects covered **$50.00**

SOUND

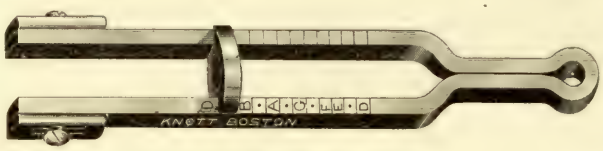
PROPAGATION OF SOUND

TUNING FORKS

In the selection of our **TUNING FORKS** we have been guided by the demands of the past which we have classified. We have, therefore, elminated certain types and added forms of greater pedagogic value. Our policy is to furnish the best at the most reasonable prices, offering a line which will give the prospective buyer a range for choice.

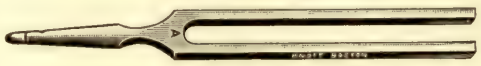
For ordinary work, we recommend our Nos. **51–50** to **51–87.** These forks are accurately tested and have, within a very small percentage of error, the stated vibration frequencies. For the highest scientific work, we recommend Nos. **51–90** to **51–125.**

All forks are tuned to the Physical Pitch, and, when a fork is mounted on Resonant Case, it must be understood that the case is accurately tuned in resonance with the fork.



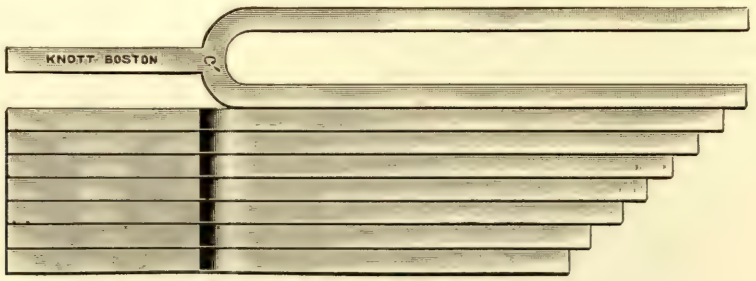
No. 51–50

51–50 UNIVERSAL PATENT ADJUSTABLE TUNING FORK, U. S. Standard Pitch, nickel-plated . . . **$1.18**



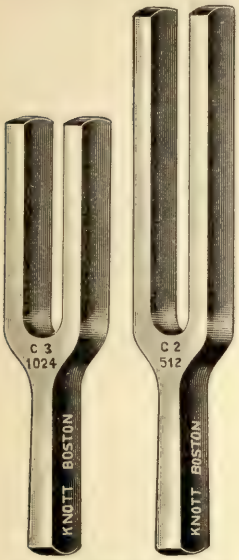
No. 51–55

51–55 TUNING FORK, 12 centimeters long, best polished steel, Pitch A **$0.16**
51–57 ——, 12 centimeters long, best polished steel, Pitch C . . . . . **.16**

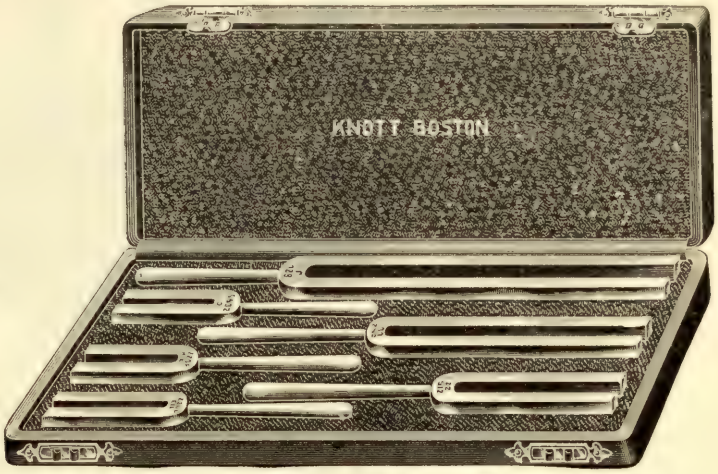


Nos. 51–75 to 51–87

51–65 TUNING FORK, Pitch C = **128** VPS. about 25 centimeters long **$3.00**
51–75 ——, Pitch C′ = 256 VPS. about 22 centimeters long **1.20**
51–76 ——, Pitch D = 288 VPS. about 21 centimeters long **1.45**
51–77 ——, Pitch E = 320 VPS. about 20 centimeters long **1.45**
51–78 ——, Pitch F = 341⅓ VPS. about 20 centimeters long **1.45**
51–79 ——, Pitch G = 384 VPS. about 19 centimeters long **1.45**
51–80 ——, Pitch A = 426⅔ VPS. about 19 centimeters long **1.25**
51–81 ——, Pitch B = 480 VPS. about 18 centimeters long **1.25**
51–82 ——, Pitch C^2 = 512 VPS. about 18 centimeters long **1.10**
51–85 TUNING FORKS, set of four, giving the Major Chord, C′, E, G, and C^2 . . . . . **5.00**
51–86 MOUNTED TUNING FORKS, set of four, C′, E, G, C^2, as listed above, mounted on resonant cases Duty Free **12.75**
51–87 TUNING FORKS, set of eight, C^1 to C^2, giving full Octave. Same forks as Nos. **51–75** to **51–82** . . **9.75**



Nos. 51–90 to 51–106



No. 51–115

51–90 **NORMAL TUNING FORKS** of excellent quality, finely nickel-plated, accurately adjusted. Set of eight forks, from C = 64 VPS to C = 128 VPS, the largest fork about 40 centimeters long, the smallest about 36½ centimeters . . . . . Duty Free **$34.00**

51–95 ——, same quality as above, set of fifteen forks, from C = 64 VPS to C^1 = 256 VPS. The largest fork about 44 centimeters long, the smallest about 23 centimeters . . . . . Duty Free **52.50**

51–100 ——, same quality as above, set of eight forks, from C = 128 VPS to C^1 = 256 VPS. The largest fork about 36½ centimeters long, the smallest about 23 centimeters **18.75**

51–105 **EXTRA HEAVY TUNING FORK,** C = 64 VPS, 44 centimeters long . . . . . Duty Free **6.25**

51–106 ——, C = 128 VPS, 35 centimeters long . . . . . Duty Free **5.50**

51–115 **STANDARD NORMAL TUNING FORKS,** highest quality and precision, especially designed for research in acoustical phenomena. Set of six large nickel-plated Forks, C = 128 VPS, C^1 = 256 VPS, C^2 = 512 VPS, C^3 = 1024 VPS, C^4 = 2048 VPS, and G^4 = 3072 VPS. Each with a vibration period of 30 seconds. Enclosed in handsome plush-lined case . . . . . Duty Free **37.00**

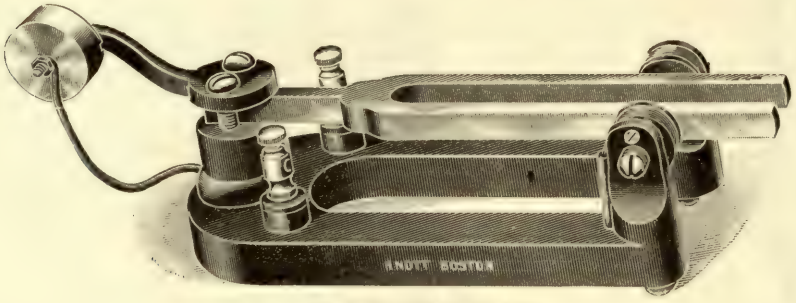
51–120 **STANDARD NORMAL TUNING FORK,** finest quality, highest precision, worked out of a heavy piece of steel, not cast, with certificate of accuracy from the Physikalische Techniche Reichsanstalt. Enclosed in neat case . . . . . Duty Free **8.50**

No. 51–125

51–125 **FIFTY-CENTIMETER TUNING FORK AFTER BEZOLD,** for demonstrating the minimum limit of the normal ear for sound.

This is a polished steel fork, 500 millimeters long, with a 350 millimeter prong, each prong 21 × 9 millimeters. Each fork has received the most painstaking care in construction and is carefully adjusted. Adjustable ballast weights are provided giving vibration frequencies from 15 to 24. Handsomely polished . . . . . Duty Free **$24.25**

ELECTRO-SYNCHRONISM-DRIVEN RECORDING FORK



Nos. 51–135 to 51–140
Patent pending.

In our electro-synchronism-driven tuning fork we believe that improvements of the greatest importance have been made in the fundamental instrument, improvements which will give the closest approach to an ideal fork. In our method, an especially designed Microphone is mounted on the base of the instrument. This Microphone picks up the vibrations thrown from the fork, and in turn varies the strength of the electro-magnets which actuate the fork. leaving the prongs free to vibrate unhampered by contacts or springs such as were formerly used. In use the binding posts are connected to the source of current, 4 cells of dry battery being recommended.

The synchronism that takes place is shown in a very striking manner. Starting with an almost imperceptible vibration, the fork gradually reaches its highest amplitude, when it will continue to give forth a tone of great purity, with absolute freedom from all other foreign sounds or vibrations which have proved so troublesome in forks constructed by ordinary methods. The synchronism method insures the fork giving its actual tone, a result not obtained by any other method.

Electrically Driven Tuning Forks in which the electric contact is made directly on the prongs either by a spring attached to one prong or by a platinum contact soldered to it, have the following objections: —

1. **The prong of the fork carrying the contact or spring is dampened,** and the fundamental tone of the fork is radically changed thereby.
2. **The vibration of the fork is forced to an unnatural pitch** by means of the sudden rush of current due to its intermittent contact.
3. **The contact point emits a sound** often sufficient to obscure the fundamental tone of the fork.
4. **An adjustment that will give the natural clear tone of the fork is impossible,** owing to the unavoidable noise due to this method of vibration.

In the **Electro-Synchronism-Driven Tuning Fork** we justly claim the following features: —

1. The fork has nothing to carry.
2. The vibration is absolutely dependent upon the natural period of the fork.
3. There are no parts of the apparatus to take up vibrations and give any undesirable sounds.
4. The fork is actuated by a current that varies in strength from maximum to minimum in absolute synchronism with its own period.
5. The vibrating apparatus is absolutely distinct and unattached to the fork and hence produces no distortion in vibration.

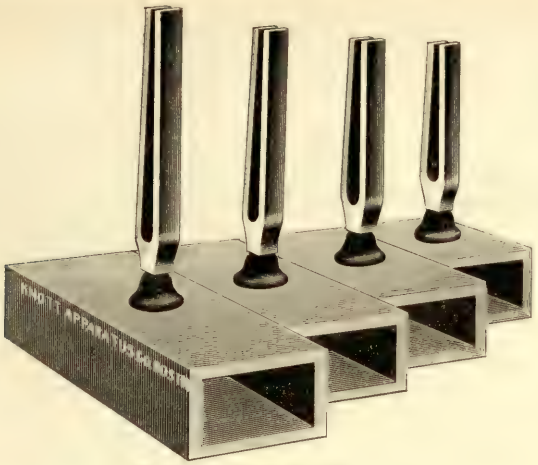
As the principal object of this apparatus is to maintain for a considerable period a uniform tone and vibration coming from a fork having a definite vibration period, we list the apparatus designed for adjusted forks of 128 and 256 vibrations. We desire to call particular attention to the fact that these forks are of the best quality, furnished us by a prominent European manufacturer.

51–135 **ELECTRO-SYNCHRONISM-DRIVEN RECORDING FORK,** including base and imported fork No. **51–106**, 35 centimeters long, 128 VPS **$17.25**

51–137 ——, same as above, but with No. **51–75** fork, 22 centimeters long, 256 VPS **9.50**

51–140 **UNADJUSTED FORK, large size,** for use with above. It is frequently desirable to use an electrically driven tuning fork designed so that the stylus for recording the vibrations on a moving surface may be attached; also one in which the mirrors for use in tracing Lissajous' figures may be used. Where these attachments are added the absolute vibration of the fork cannot, of course, be depended upon, since the prong must carry a load. For this work, therefore, a fork which has not been especially adjusted is entirely adequate. The fork which we furnish under this number is one of unusually substantial construction, giving about 100 vibrations per second and fitted with milled head binding screws on the end of the fork, to which the recording stylus may be attached. In the end of the prong there is provided a threaded hole for holding the mirrors listed below for use in Lissajous' experiments.
Complete with stylus **6.75**

51–142 **MOUNTED MIRRORS,** with threaded stems fitting the holes of the fork used in the above and especially adapted for Lissajous' experiments . . . . . Per Pair **2.50**

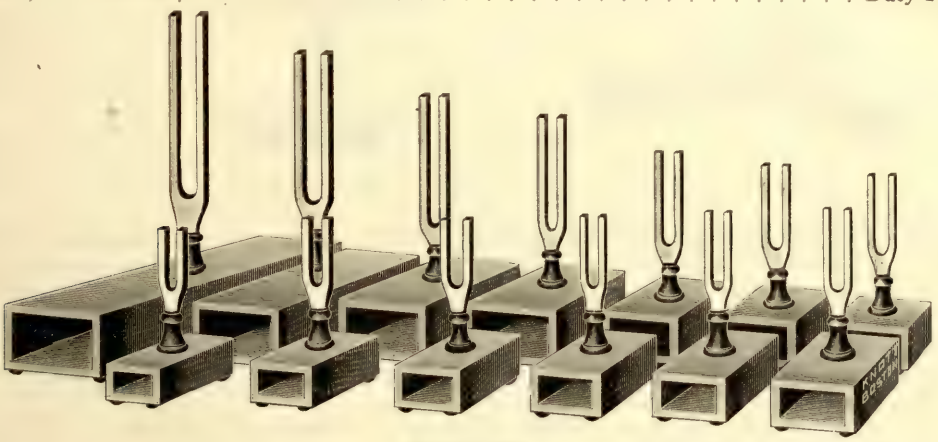


Nos. 51–150 to 51–161

51–150 **LARGE MOUNTED TUNING FORKS,** most careful workmanship, highest accuracy, mounted on synchronized resonant cases. Set includes four large forks from $C^1 = 256$ VPS to $C^2 = 512$ VPS, each mounted on a separate case. With rubber hammer . . . . . Duty Free **$34.00**

ABOVE FORKS SEPARATELY LISTED

51–155 **LARGE MOUNTED TUNING FORK,** $C^1 = 256$ VPS . . . . . Duty Free **9.25**
51–157 ——, E = 320 VPS . . . . . Duty Free **9.00**
51–159 ——, G = 384 VPS . . . . . Duty Free **9.00**
51–161 ——, $C^2 = 512$ VPS . . . . . Duty Free **8.75**

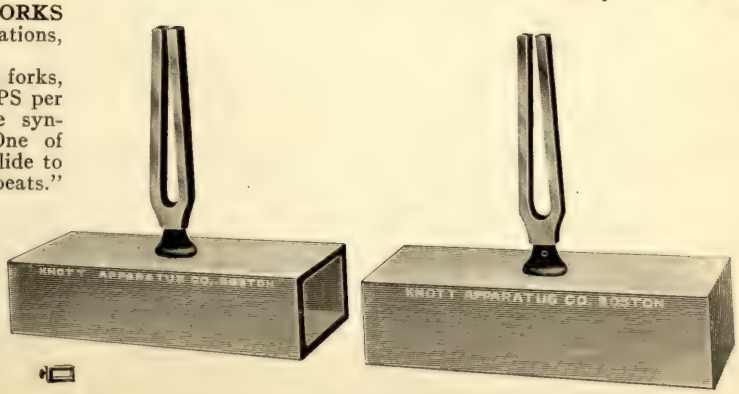


No. 51–180

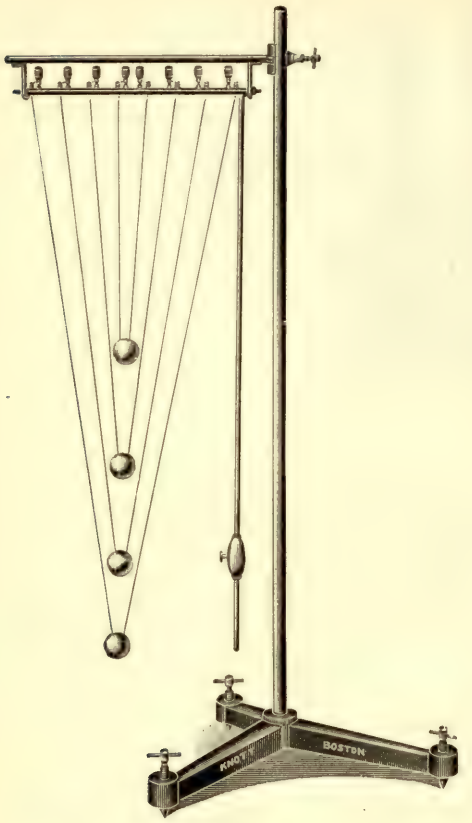
51–175 **LARGE MOUNTED TUNING FORKS,** same quality as above. Set of eight forks, giving the Octave, $C^1 = 256$ VPS to $C^2 = 512$ VPS, each mounted on resonant case . . . . . Duty Free **$53.00**
51–180 ——, same as above, set of thirteen, from $C^1 = 256$ VPS to $C^2 = 512$ VPS; each mounted on synchronized resonant case . . . . . Duty Free **68.00**

51–190 **SYMPATHETIC TUNING FORKS** for showing sympathetic vibrations, also " beats."
Consists of a pair of large tuning forks, accurately adjusted to 256 VPS per second, mounted on separate synchronized resonant cases. One of the forks is supplied with a slide to destroy the unison to show " beats."
Complete with large rubber hammer, Duty Free **$13.50**

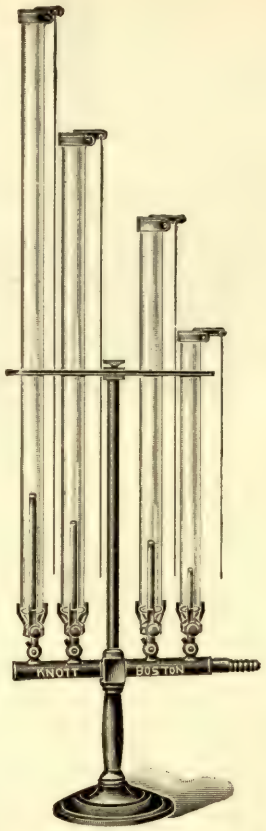
51–192 ——, extra large, same quality as above, but accurately adjusted forks of 128 VPS, Duty Free **24.00**



No. 51-190



No. 51–205



No. 51–212

No. 51–220

51–205 **THE MORSE SYMPATHETIC VIBRATION APPARATUS,** for the study of sympathetic vibrations in simple pendulums and for determining under what conditions two bodies will vibrate in sympathy. The apparatus clearly shows what is meant by the expression, "natural period of swing."

The apparatus consists of a tripod stand on which are mounted the vibration apparatus consisting of four simple pendulums in bi-filar suspensions and a compound pendulum with adjustable disc bob, all suspended from a common swivel support.

If the compound pendulum is set vibrating the simple pendulum whose vibration period is synchronous will begin to vibrate.

Apparatus complete with tripod stand **$8.25**

51–206 ——, same as above but without tripod stand and support **5.25**

Tripod Stand above illustrated is

22–131 TRIPOD STAND with leveling screws **3.00**

51–210 **CHEMICAL HARMONICON or SINGING FLAME,** showing that the air in an open tube may be made to give a sound by means of a luminous jet of gas.

The apparatus consists of a tube about 2 centimeters in diameter of the carefully calculated length to respond to the jet or the burner, also supplied with the apparatus.

Tube complete with burner **2.50**

51–212 **CHEMICAL HARMONICA**, similar to No. **51–210**, but designed to sound the chord.

The apparatus consists of four tubes similar in design to No. **51–210**, but all mounted on a common stand with special burner.

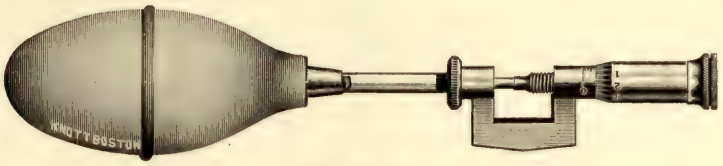
Complete as illustrated . . . . . Duty Free **14.50**

51–220 **ROSE BURNER and TUBE,** for sensitive flames with any gas pressure.

The apparatus consists of burner and gauze support as illustrated. In use, the gauze must be adjusted to such a height that the flame burns quietly **2.50**

51–225 **GAS BAG** for use with Nos. **51–210** to **51–220** for regulating gas pressure in producing sensitive flames.

Complete with brass stop-cock **1.50**



No. 51–240

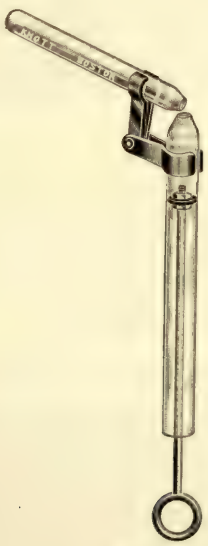
51–240 **GALTON'S WHISTLE** for determining the highest limit of audibility, — calculated vibrations up to 85,000 per second possible.

This is an accurately constructed instrument, all dimensions calculated to a scientific nicety. Each part is carefully fitted, neatly polished, and lacquered. Results possible fully warrant its expense. **$8.75**

51–243 **GALTON'S WHISTLE** for determining the upper limit of audibility.

This instrument is similar in appearance to No. **51–240**, but designed and constructed by Dr. M. Th. Edelmann. It has an improvement in form of a double adjustment and a large throat. It attains the highest degree of accuracy and is handsomely finished throughout. Complete directions and valuable data are furnished with each instrument.

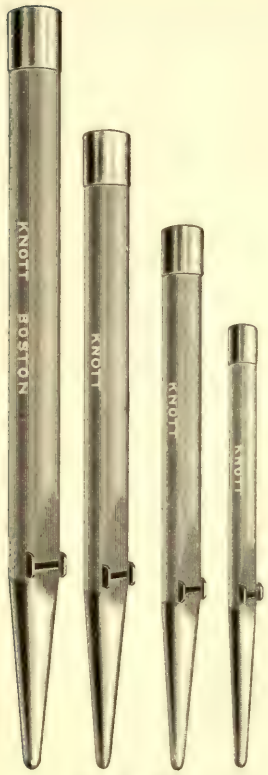
Enclosed in leather case . . . . . Duty Free **16.50**



No. 51–250

51–250 **GLASS WHISTLE WITH SLIDING PISTON** for determining the " fundamentals " of closed pipes.

This consists of a glass tube in which is a sliding piston and to which is fastened a second tube in such a position that air blown through it will cause the air column in the first tube to emit a tone which may be proved the " fundamental " of the tube **$1.25**



No. 51–275

No. 51–290

No. 51–295

51–275 **ORGAN PIPES,** set of four giving the Chords, C^1, E, G, and C^2.

These pipes are carefully constructed from metal, and from actual experimentation are found to give the best results, far in excess of pipes constructed of wood. They are especially constructed for us and we have added to their pedagogic value by the attachment of a Sliding Tuning Tube which is designed to change the tone by lengthening the tube.

These pipes will be found a valuable addition to any laboratory and their handsome appearance will certainly add to the appearance of the scientific equipment . . . . . Duty Free **$9.50**

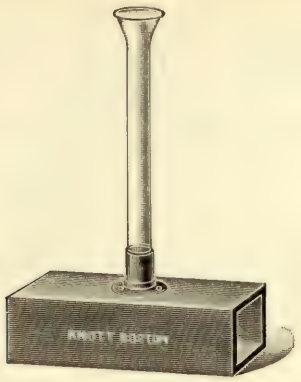
51–285 ——, same as above, but a full set of eight pipes sounding the octave from C^1 to C^2 . . . Duty Free **18.75**

51–290 **DEMONSTRATION ORGAN PIPE** for showing the vibrating segments and nodes of an organ pipe by means of a membrane.

This consists of a wooden pipe, one side of which is of glass. Fitting within this pipe is an adjustable membrane, the height of which in the tube can be regulated by means of a rod to which the membrane is attached.

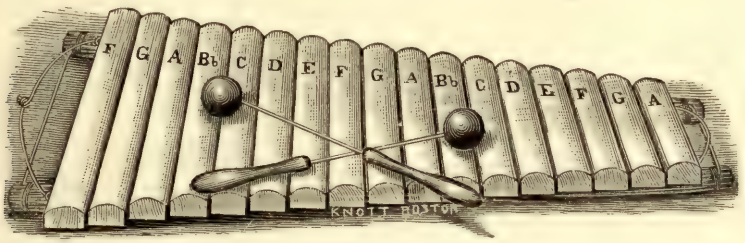
On lowering the membrane, in the tube, until it reaches a node, a pure tone is produced; but on raising or lowering the membrane a few centimeters, a harsh note is given out. On covering the membrane with a little sand or cork dust and changing its height in the tube, it will be seen that the sand or dust is disturbed at all positions except at the nodes **4.00**

51–295 **DEMONSTRATION ORGAN PIPE WITH MOVABLE STOP** for sounding two octaves with tones and semi-tones distinctly marked on the frame which operates the stop **4.00**



No. 51–310

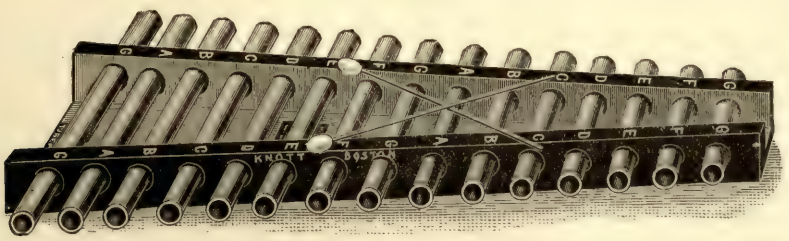
51–310 MOUNTED TUBE for showing transmission of sound by liquids.
This apparatus consists of a glass tube with funnel-shaped open end, mounted on resonant case.
If stem of vibrating fork is held at open end it may be shown that no sound is transmitted; if, however, the tube is filled with water and the stem touches the surface of the liquid, sound is transmitted.
Duty Free **$8.50**



No. 51–315

51–315 XYLOPHONE showing musical tones from vibrating wooden bars. Consists of fifteen maple bars mounted on wood frame and accurately tuned to sound two octaves. With two hammers . . **$2.50**

51–320 METALAPHONE for showing musical tones emitted by vibrating metal. Consists of twelve metal plates carefully tuned and mounted in ornamented wooden frame. With two hammers **2.15**

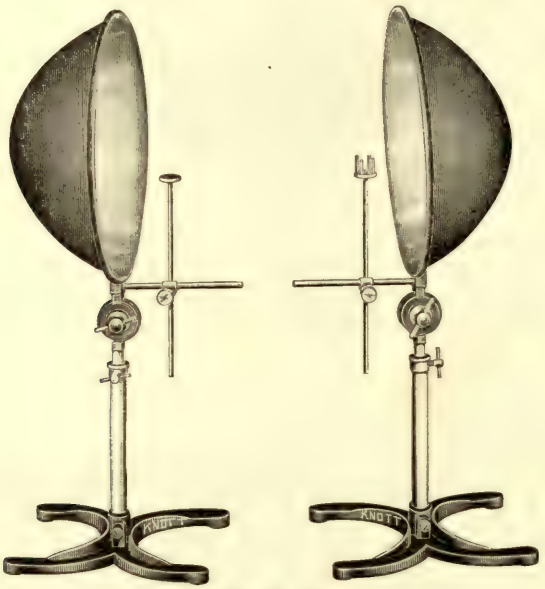


No. 51–325

51–325 TUBEPHONE showing musical tones emitted by vibrating tubes. Consists of fifteen brass tubes highly polished, mounted in wooden frame. With two hammers, in cardboard box **$2.75**

51–330 GAMUT BELLS sounding tones from A below middle C to the first A above the treble staff, 25 bells in number, of finely polished nickel-plated steel, giving pure, clear, and mellow tones.
We advise the purchase of this set in that the tones are true and in that the pedagogic value fully warrants the expense . . . . . Duty Free **8.25**

REFLECTION, REFRACTION AND INTERFERENCE OF SOUND WAVES



No. 52–10

52–10 THIRTEEN-INCH UNIVERSALLY ADJUSTABLE TRUE PARABOLIC REFLECTORS for demonstrating Reflection of Sound, Heat and Light Waves.

In offering for sale our Improved Reflectors we desire to emphasize the **TRUE PARABOLIC SURFACES.** The curves of these surfaces have been accurately calculated and drawn and then by painstaking processes a chuck has been turned to the true parabolic curve. Our Reflectors are all spun from this chuck. The reflecting surface is then highly polished and heavily nickel-plated, presenting an excellent surface without waves.

The Reflectors are mounted in a two-part circular casting in such a manner as to entirely obviate any danger of distorting the surfaces. This two-part casting is brought together at the bottom, where it makes a swivel junction with a rod which telescopes into the supporting base.

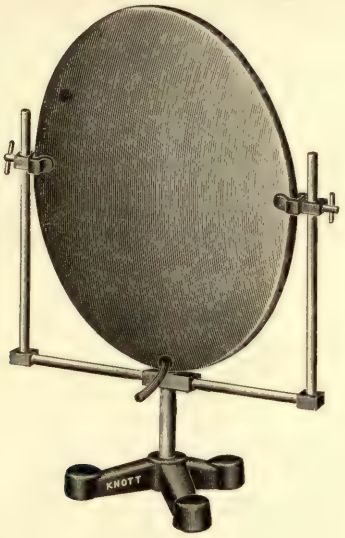
The holders and attachments are all of special design which allow of both coarse and fine adjustments. We, therefore, secure a tilting movement for the Reflectors, an adjustment for proper height, and universal movements for each attachment.

In illustrating Reflection of Sound a simple experiment is possible by attaching a watch to one of the carriers at the focus of one reflector; if now one end of a flexible tubing is placed at the focus of the other reflector attached to the carrier and the other end terminating in a large funnel, megaphone, or horn, the ticking of the watch may be heard by the majority of the class.

The finish of this instrument is fully in keeping with the design. The outer surfaces of the Reflectors are dull oxidized, the H Base bright japan, and all brass parts polished and nickel-plated.

Thirteen-Inch Universally Adjustable True Parabolic Reflectors complete as illustrated with attachments . . . . . Per Pair **$17.50**

52–15 Same as above, mounted on stand but without attachments or carriers . . . . . Per Pair **13.50**



No. 52–30

52–30 SOUND LENS, for experiments on the refraction of sound.

The apparatus consists of a double-walled rubber diaphragm re-inforced by a rolled metal ring and provided with an outlet for inflating with gas, whose refractive power is to be studied. This outlet is also convenient for regulating the curvature and hence the refractive power of the lens.

A source of sound is placed in the direction of the axis; the point is then sought on the other side of the lens at which the sound is most distinctly heard. This point will be the focus, and at all other points the sound is scarcely perceptible, showing that sound has been refracted by the lens in much the same way as light is refracted by a glass lens.

This apparatus is supported by a simple and effectively designed base and supporting arm so arranged as to give ample adjustment and full range in the angle of inclination.

Sound Lens complete, with stand, as illustrated **$9.80**

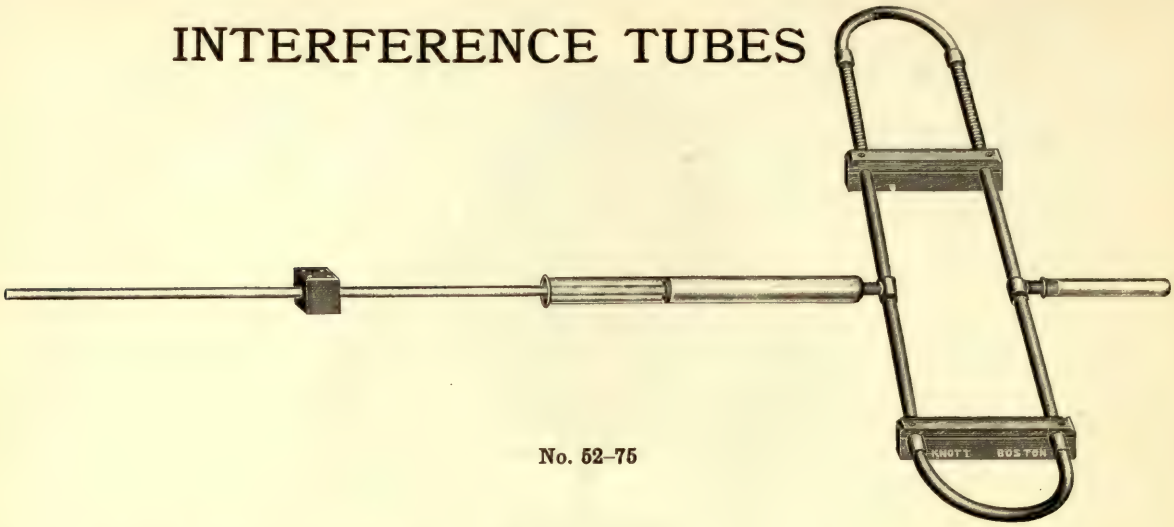
52–32 SOUND LENS only, ready for mounting on stand **6.75**

No. 52–40

52–40 EAR TRUMPET, for concentrating sound waves. This is a neatly finished metal instrument designed to reflect and concentrate sound waves **$2.50**

NOTE: We are prepared to furnish specifications and prices on phonographs particularly adapted to scientific researches.

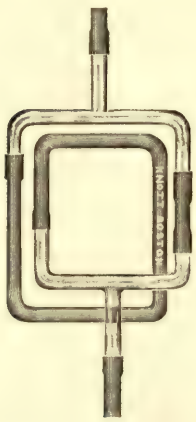
INTERFERENCE TUBES



No. 52–75

52–75 **KUNDT'S INTERFERENCE APPARATUS** for the quantitative study of Interference of Sound Waves.

This apparatus consists of two U-shaped nickel-plated brass tubes, one provided with supporting cross bars; the other has both arms graduated, telescoping into the first. To one of the parallel sides of this interference tube is attached a closed glass tube which in use contains cork dust or lycopodium powder. To the other side is attached a glass tube with supported sliding piston. In use, vibrations are set up in the piston tube with the movable telescoping part of the interference tube pushed home, then with this part so that it represents 1, 2, 3, 4, 5, etc. quarter wave-lengths. It will be noted that figures are produced with the even numbers and are not formed with the odd numbers of quarter wave-lengths . . . . . Duty Free **$15.00**



No. 52–80

No. 52–85

52–80 **INTERFERENCE TUBES after QUINCKE** for use with C^1 = 512 VPS, in illustrating interference of sound waves.

The apparatus consists of two T-shaped glass tubes of equal diameter connected as illustrated by rubber tub ng

If a tuning fork is sounded before the open end of the long tube, and the open end of the other tube is held to the ear, there will be no sound heard providing the length of the tube connecting the branches of the T-tube is one-half the wave-length of the note produced by the fork. If, however, this rubber tube be closed by pinching it, the note is at once heard.

Complete with rubber tubing as illustrated **$1.35**

52–85 **HOPKINS' METAL FORK INTERFERENCE TUBE** for use with a Chladni's Plate (see Nos. **54–129** and **54–132**) in illustrating interference of sound.

This consists of a forked metal tube with adjustable extension.

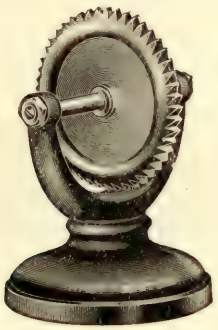
In use, the plate is bowed so that the two diagonals are distinctly formed. If the fork of the Interference Tube is held over two non-contiguous sectors, the sand strewn on the membrane is violently agitated. If the fork is held over two contiguous sectors, the sand is not disturbed. **3.15**

5–875 **CLAMP** for attaching above to stand **1.75**

5–760 **CLAMP HOLDER** for above Clamp . . . . . **.70**

VIBRATION FREQUENCY— RESONANCE

SIRENS



No. 21–245

21–245 SAVART'S WHEEL for demonstration that pitch is proportional to the number of vibrations per second.

The apparatus consists of a heavy cast toothed wheel mounted on steel pinions in a forked stand. This wheel may be rotated by means of a cord. If a card is held lightly against the teeth of the wheel during rotation, a note will be sounded, the pitch depending on the speed of the wheel . . **$7.65**

21–240 SAVART'S WHEEL for use on Rotator, consisting of four discs of metal in the periphery of which are cut teeth, the number forming a simple ratio to give a harmonic chord **2.95**

21–242 SAVART'S WHEEL, a single disc for attachment to Rotator . . . . . **.58**

21–220 SAVART'S WHEEL, COLOR AND SIREN DISC combined. (See Section **21**) **3.90**

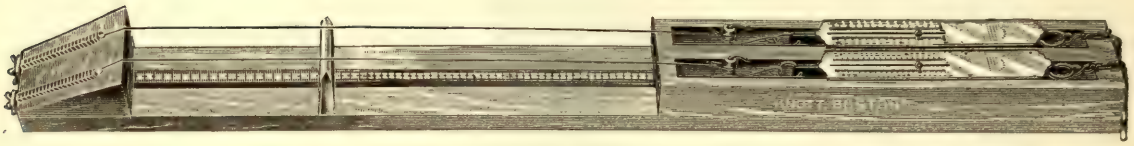
No. 53–40

53–40 CAIGNARD–LATOUR SIREN WITH COUNTERS. This is a carefully constructed scientific instrument, a product of a firm well known in Europe for accurate designs of acoustical apparatus. It is handsomely finished throughout . . . . . Duty Free **$17.25**

53–42 CAIGNARD–LATOUR SIREN WITHOUT COUNTERS. This instrument is similar in design to the one above but without counters . . . . . Duty Free **12.40**

53–45 DEMONSTRATION CAIGNARD–LATOUR SIREN WITHOUT COUNTERS. This is a greatly simplified form of the above . . . . . Duty Free **9.00**

SONOMETERS



No. 53–100

53–100 **SONOMETER** for formulating the laws governing the pitch of vibrating strings.

This sonometer combines all the features necessary to the pedagogic derivation of Laws of Tension, Laws of Length, and Laws of Masses of vibrating strings. Its principal feature is in the fact that it is self-contained, that is, no accessory weights, scale pans, etc., are needed.

It measures over all about 1½ meters and is substantially constructed of straight-grained wood. Two apartments are provided for holding the Spring Dynamometers. Fine tension is secured by wing nuts operating on screws to the ends of which are attached one end of the wires under tension. A full length metric scale with chromatic scale is provided.

Sonometer complete with three Wires, two Bridges, and two Dynamometers registering to 30 pounds by ¼ pound and 15 kilos by 100 grams **$7.25**

53–101 ——, same as above, but without Spring Dynamometers **4.00**

53–102 **SONOMETER WIRES,** set of three wires, two of same diameter and same material, the third of different diameter and different material from the other two . . . . . Per Set of Three **.35**

No. 53–115

53–115 **NATIONAL SCHOOL SONOMETER** for formulating laws governing pitch of vibrating strings.

This Sonometer has the same pedagogic features as No. **53–100**. It is more compact and of simpler construction, consisting of three wires mounted on resonant case, each wire attached at one end to a tension spring of 25 pounds capacity and at other around the shaft of a piano tension key.

Complete as illustrated, with three wires and bridge, case provided with chromatic scale. **$4.50**

53–117 **SONOMETER WIRES,** set of three wires, right length for above, — two of same diameter and same material, the third of different diameter and different material from the other two. Per set of three **.35**

No. 53–125

53–125 VERTICAL WALL FORM SONOMETER for class room demonstration and for students' experiments in formulating laws of vibrating strings.

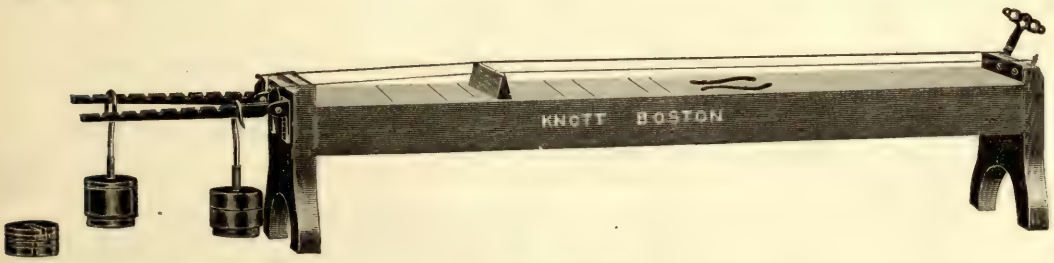
This sonometer consists of a neatly finished, well-seasoned resonant case, to the upper end of which are fastened attachments for suspending two wires; attached to the front are two meter rods to measure the lengths of the active portions of the vibrating wires, and are also used as supports for clamping the two adjustable bridges. Two guide clamps fastened at the lower end of the case are necessary to restrain the swaying tendency when weights are attached for tension.

This form will be found exceedingly convenient as it may be attached to the wall where it would take little space. It has the feature, in addition, that the tension is applied direct. As a demonstration Sonometer, it is highly recommended above all horizontal types.

Complete as illustrated, with two wires, bridge clamps, etc., but without hanger and weights **$11.50**

53–127 SONOMETER STRINGS, a pair of strings as used in above, of diameter of 0.014 and 0.028 inch . . . . . Per Pair **.25**

WEIGHTS AND HANGERS. Section **16.**



No. 53–135

53–135 LEVER TENSION SONOMETER for study of laws of vibrating strings.

In this apparatus the tension on the wires is regulated by means of weights sliding on levers. The resonant case is of well-seasoned spruce and is provided with a chromatic scale.

Complete with pair of strings and bridge but without hangers and weights **$7.80**

53–137 DIRECT TENSION SONOMETER, same as above, but fitted with pulleys over which tension is secured by means of cords to which are attached weights.

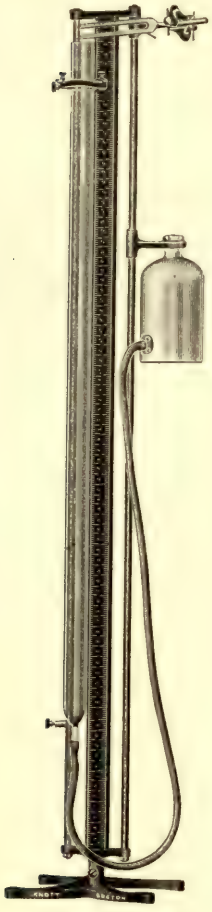
Complete with two weight hangers but without weights **7.80**

53–139 KEY TENSION SONOMETER, same as above, but fitted with tension keys in place of pulleys.

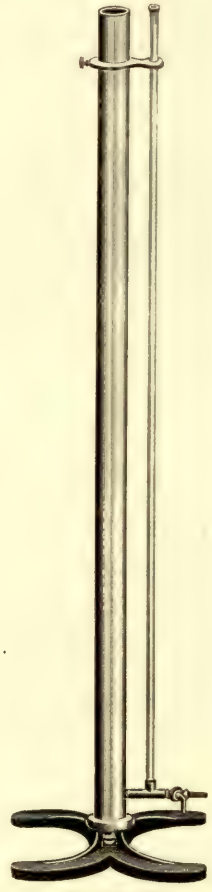
Complete with two wires and bridge **7.25**

WEIGHTS AND HANGERS. Section **16.**

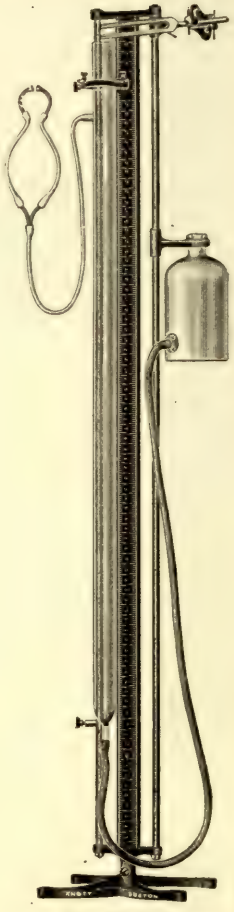
RESONANCE TUBES



No. 53–200



No. 53–205



No. 53–215

53–200 KNOTT'S ONE HUNDRED AND FIFTY CENTIMETER RESONANCE APPARATUS, for determining the wave length of a tuning fork; also for determining the velocity of sound in air.

The apparatus consists of a metal upright with metric scale mounted on our H-base. To the rods of this upright are attached the clamps for holding the required accessories. Thus the resonant tube is supported at the left by Nos. **5–887** and **5–889** Clamps, and the reservoir at the right by No. **5–885** Clamp, the fork at the top by one each of our Nos. **5–450** and **5–891** Clamps. The apparatus is designed to support a tube of sufficient dimensions so that with a $C^1 = 256$ V.P.S. Fork a resonating column of $\frac{3}{4}$ of a wave length is possible.

Apparatus neatly finished throughout, complete as illustrated but without fork **$8.50**

51–75 TUNING FORK, $C^1 = 256$ V.P.S. **1.20**

53–205 FIVE-FOOT METAL RESONANCE TUBE WITH WATER LEVEL INDICATOR, for determining the Velocity of Sound in Air; also for determining the Wave Length of a Tuning Fork.

This is a metal tube, five feet in height, mounted on our H-base. At the lower end of this tube is a lateral tube with stop-cock, which can serve either as an inlet or as an outlet tube as may be desired. A glass tube of the same length as the metal tube connected to this lateral tube serves as an indicator for registering the length of the resonating air column.

This design combines advantages of other types, and has the further feature of facility of measurements of air columns, ease in varying height of water level, and extreme durability **6.25**

53–215 ONE HUNDRED AND FIFTY CENTIMETER RESONANCE APPARATUS, after Ames & Bliss' "Manual of Experiments in Physics," Experiment 40.

This apparatus consists of a long glass tube with a small side tube attached near the open end, the bottom of which is tapered so as to join with a length of rubber tubing connected either with the water tap or as illustrated with a reservoir for water.

This apparatus is mounted as illustrated on a supporting stand, as described above.

Complete as illustrated, but without tuning fork **9.25**

53–220 RESONANCE APPARATUS, after Ames & Bliss' "Manual of Experiments in Physics," Experiment 40.

This apparatus is exactly the same as the one above described, except that it is not mounted and is supplied with a small reservoir in place of the large one illustrated **3.20**

No. 53–230

53–230 HORIZONTAL RESONANCE TUBE, for measuring the velocity of sound in air.
This is a glass tube mounted horizontally on a convenient wooden support. It is provided with a sliding piston for regulating the length of the active air column. This will be found a convenient students' apparatus **$2.25**

53–235 GLASS RESONANCE TUBES, with smooth ends, for use in resonance experiments.

	a	b	c
Length, centimeters	55	110	110
Diameter, centimeters	3.5	3.5	4
Each	**$0.85**	**1.20**	**1.50**

31–250 RESONANCE GLASS JARS, for use in resonance experiments. These jars are of clear white glass, with foot and rim.

	a	b	c	d	e
Size, inches . . .	12 × 1½	12 × 2	15 × 2	15 × 3	18 × 3
Each	**$0.40**	**.45**	**.75**	**.95**	**1.25**

TABLE OF MUSICAL NOMENCLATURES

Name of Note	C	D	E	F	G	A	B	2C
Frequency in terms of fundamental	m	9/8 m	5/4 m	4/3 m	3/2 m	5/3 m	15/8 m	2 m
Intervals		9/8	10/9	16/15	9/8	10/9	9/8	16/15
Name of note in vocal music . . .	do	re	mi	fa	sol	la	si	do
Scientific Scale	**256**	**288**	**320**	**341**	**384**	**427**	**480**	**512**

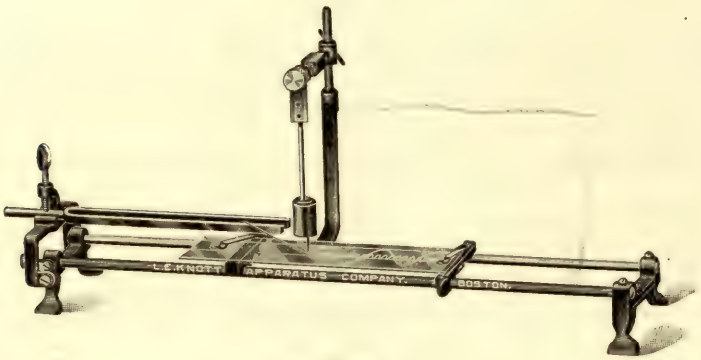
FREQUENCIES OF PARTIALS OF THE HIGHER NOTE FOR SOME OTHER INTERVALS
TONIC = 256 V. P. S.

	Tonic	Fifth	Fourth	Major Sixth	Major Third	Minor Third
Fundamental	256	384	341	427	320	307
1 overtone	512	768	682	854	640	614
2 "	768	1152	1023	1281	960	921
3 "	1024	1536	1364	1708	1280	1228
4 "	1280	1920	1705	2135	1600	1535
5 "	1536	2304	2046	2562	1920	1842
6 "	1792	2688	2387	....	2240	2149
7 "	2048	....	....	....	2560	2456
8 "	2304	....	....	....	....	....

STUDY OF SOUND VIBRATIONS

RECORDING APPARATUS — LISSAJOUS' CURVES — CHLADNI'S PLATES MANOMETRIC FLAME APPARATUS — SONOGRAPH

GRAPHIC REPRESENTATION OF SOUND



No. 54–15

Patented Aug. 13, 1907

54–15 KNOTT'S UNIVERSALLY ADJUSTABLE VIBROGRAPH, for determining the vibration frequency of a tuning fork.

The results of experience have demonstrated that a Vibrograph built of wood has many objectionable features. We have, therefore, discarded wood altogether in this, our new design. Two nickel-plated rods held firmly in end supports form the track along which the carriage bearing the smoked-glass plate moves freely. An upright fastened to one track bears the rod to which is fastened the clamp supporting the pendulum. The tuning fork, to one prong of which must be fastened a bristle, is clamped as pictured at left of illustration in a frame which is adjusted by means of a thumb nut and which in turn adjusts the plane of the fork.

In addition to the substantiality of this design, our claims for accuracy with a minimum of trouble are fully warranted. The handsome appearance of the instrument will enhance its value as an acquisition in any well-equipped laboratory.

Complete as illustrated, but without fork **$4.00**

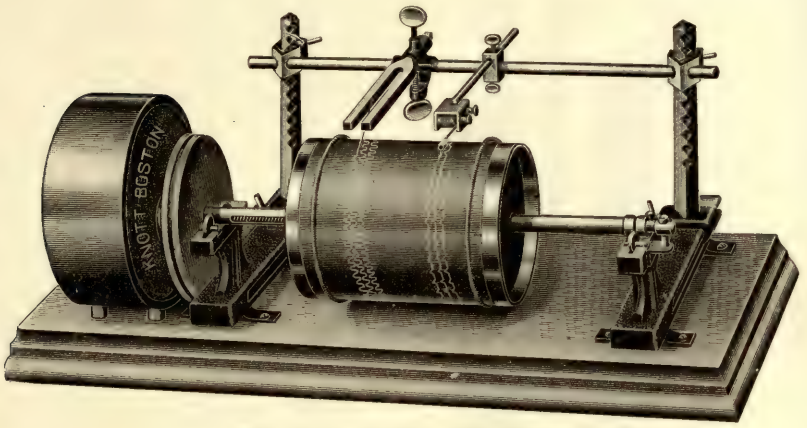
TUNING FORKS. SECTION 51

54–17 EXTRA GLASS PLATES, for use with above **VIBROGRAPH** . . . . . Each **$0.10**

54–25 BRISTLE STYLUS AND FIXATIVE, for use on a Tuning Fork when it is desired to record the vibrations on a smoked or coated plate or drum . . . . . **.25**

VARIABLE SPEED AND MULTIPLE RECORDING KYMOGRAPH AND RECORDING DRUM

With Invisible Non-Projecting Thread Feed



Nos. 54–30, 54–35 and 51–75

In the design above illustrated it has not been our purpose to produce an inexpensive instrument, but rather one which will meet all conditions perfectly. The same instrument may be operated either by a clock movement or by a belt from an outside motor or by hand. In case the clock movement is used it is attached as shown in the illustration and may be easily removed by the loosening of a single screw.

DIMENSIONS. The cylinder is 12½ centimeters in diameter, 16½ centimeters long, with a 16-centimeter feed.

RANGE. Ample room is provided for the simultaneous use of four tuning fork attachments or six recording pens. It will be seen, therefore, that our design may be used in much of the advanced work done in Botany where a record on a moving drum of the growth of a considerable number of plants under varying conditions is desired.

For instance, should one wish to take exact records on a single sheet of the continuous operation of six different plants in six different greenhouses, no two being subject to the same conditions, this can readily be done and a most satisfactory record for direct comparison produced.

VARIABLE SPEED. When the instrument is actuated by a belt from an outside motor, the speed may be regulated within the limit of the motor or the relative sizes of the pulleys. When operated by the clockwork, three speeds are possible, the change being made by the meshing in and out of gears. Periods obtained are as follows: One revolution in 24 hours, one in 12 hours, or one in 6 hours. Clock movement furnished is a standard high-grade eight-day movement, especially adapted for this Kymograph.

FEATURES. We desire to call particular attention to the following features:—

1. Frictionless Rollers upon which the shaft is rotated.
2. Method of mounting the cylinder so as to give it both a revolving and horizontal movement along the shaft without the shaft extending beyond the bearings more than is shown in the illustration. This feature prevents frequent breakage in handling and enables it to be used in much less space. The clamps for holding the recording device give to this instrument a range of usefulness not heretofore attained.
3. The upright supports are allowed a back and forward movement on the lathe bed, the attachment being the same as our well-known T-Beam attachment.
4. The vertical adjustment is given by a cleverly designed clamp and a series of notches in the upright. A rigidity and range not found in any other instrument are thus secured.
5. Screws of different pitches are provided for the purpose of adapting the forward movement to the nature of the record to be made.

It will therefore be seen that with the various features we have perfected, together with the quality of workmanship employed, we have produced a Kymograph and Recording Drum of the very highest grade, capable of a great variety of uses.

54–30 **VARIABLE SPEED KYMOGRAPH,** as above described, with clock movement and invisible feed, complete as above illustrated, but without tuning fork and time marker **$47.50**

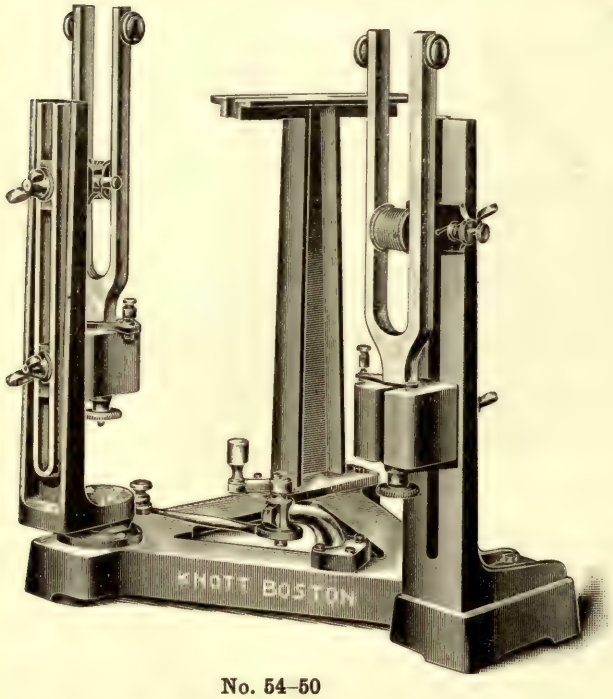
54–32 ——, same as above, but without clock movement, arranged for either hand or belt drive, without tuning fork or time marker **35.00**

54–35 **TIME MARKER.** We have modified the standard form of Kymograph Time Marker only to the extent of securing a better continuous record than is ordinarily obtained. The form, however, is much the same as is supplied for practically all Kymograph work **6.50**

54–37 **RECORD SHEETS.** Special size and divisions, to fit the cylinder. Divisions represent 10 minute, 5 minute, or 2½ minute periods when the drum is operated by clock work . . . . . Per Fifty **2.35**

TUNING FORKS. Any tuning fork under 10 inches in length listed in Section **51** may be used on this apparatus.

LISSAJOUS' CURVES APPARATUS



No. 54–50

54–50 LISSAJOUS' CURVES APPARATUS, IMPROVED MODEL, for demonstrations of parallelly and vertically combined vibrations.

Mounted on a heavy metal base are the supports for the fork holders, — one to support the fork in a horizontal position and the other two in a vertical position, one of the latter capable of being turned backward and forward by means of a small crank.

The forks supplied with the apparatus are 250 millimeters in length and have a vibration frequency of 128 V.P.S. They are substantial in structure and especially designed to give a continuous vibration of large amplitude. Each fork is kept in vibration by electro-magnets with which each carrier is supplied. By means of two riders which are furnished with the apparatus the pitch of a fork can be slightly changed for causing beats.

With addition of a Projection Lantern and a Lens, the curves can be projected very beautifully on a screen.

Apparatus complete with two forks . . . . . Duty Free **$84.00**

54–55 LISSAJOUS' CURVES APPARATUS, same as above, but without the movable upright and crank adjustment. Complete with two forks . . . . . Duty Free **59.50**

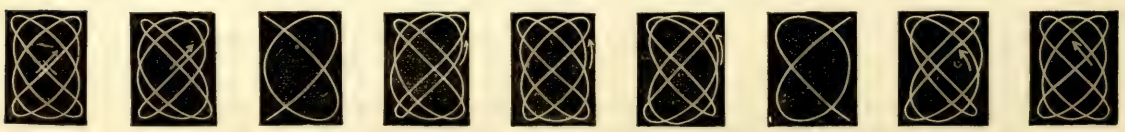
Luminous image on the screen when the Tuning Forks are in unison.

0 ⅛ ¼ ⅜ ½ ⅝ ¾ ⅞ 1

Luminous image when the difference between the Tuning Forks is an octave.

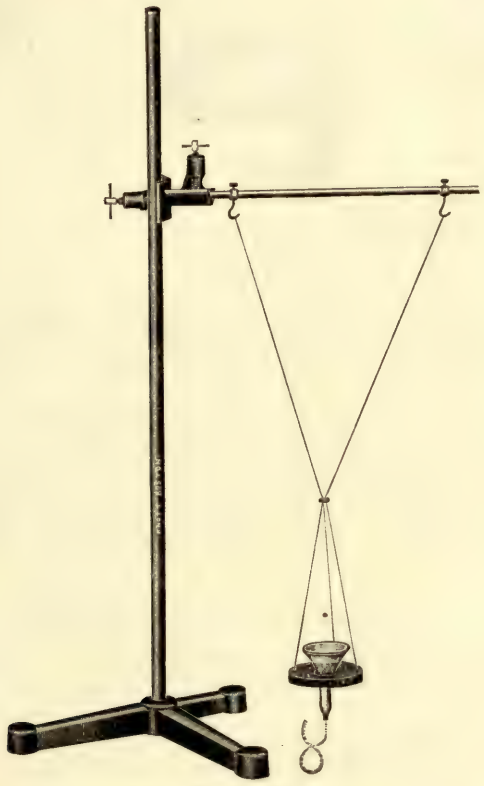
0 ⅛ ¼ ⅜ ½ ⅝ ¾ ⅞ 1

Luminous images when the numbers of vibrations are as 3 : 4.



0 1/24 1/12 3/24 1/6 5/24 1/4 7/24 1/3

Y PENDULUM
LISSAJOUS' FIGURES APPARATUS



No. 54–90

The one distinctive item shown in the above illustration is the following:

54–90 Y PENDULUM (SAND PENDULUM). This pendulum consists of a heavy bob suspended by two cords, sliding along which is a small brass ring whose office is to vary the length of the stem of the Y, thus modifying the conditions upon which the relative phases and amplitudes depend. As this bob vibrates, fine sand contained in the funnel-shaped reservoir is allowed to trickle forth, thus tracing the path of the vibrating pendulum.

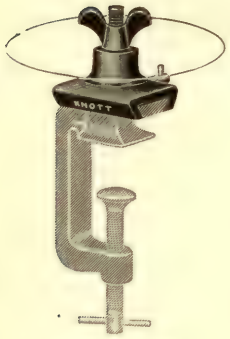
If the bob vibrates in the plane of the paper, the effective length is from the adjustable brass ring to the bob; if it vibrates at right angles to this plane, it is the distance from the support rod to the bob. The periods, therefore, will be different and independent. By adjusting the two lengths by means of the ring, the bob may be made to describe various Lissajous' Figures.

Y Pendulum only without support of any kind **$0.90**

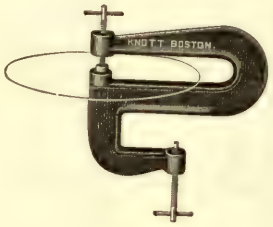
Other apparatus illustrated has all been previously listed as follows:

22–130	**UNIVERSAL STAND**	**$2.00**
5–770	**HARCOURT RIGHT ANGLE CLAMP**	**.95**
5–10e	**SUPPORT ROD,** 40 centimeters long, 10 millimeters diameter	**.29**
5–645	**HOOK COLLAR** (two required) . . . . . Each	**.22**

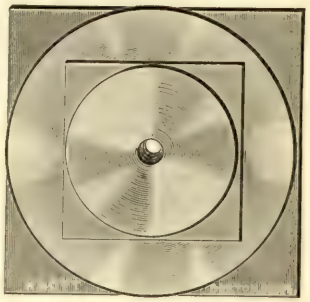
CHLADNI'S PLATES



No. 54–125



No. 54–127



Nos. 54–129 to 54–132

54–125 CHLADNI'S FIGURES APPARATUS, for showing that Vibrating Plates contain nodal lines which vary in number and position according to the form and size of the plate and the position of excitation.

The apparatus consists of two plates of polished brass, one 6 inches in diameter, the other 6 inches square, each with hole in center for attachment to a table clamp. The nodal lines on the plate are made visible by covering the plate with fine sand before it is made to vibrate. As soon as vibration begins the sand leaves the vibrating parts and accumulates in nodal lines. The position of these lines may be determined by touching on points at which it is desired to produce them.

Complete as illustrated with two 6-inch plates, one square the other round, but without T-beam Basic Clamp "A" **$2.60**

Basic Clamp illustrated above and listed elsewhere is:

5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "A" **$1.15**

54–127 CHLADNI'S FIGURES APPARATUS, large size, consisting of two 10-inch polished brass plates, one square, the other round, with table clamp for attachment to the table top **5.40**

5–1085 CHLADNI'S PLATE INTERLOCKING CLAMP ATTACHMENT, for use with our Universal T-Beam Basic Clamp "A." See No. **54–125**.

Attachment only . . . . . **.60**

5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP "A" to which may be fastened the above attachment, in manner illustrated in No. **54–125** **1.15**

54–129 CHLADNI'S PLATE, polished brass, 6 inches in diameter **1.00**

54–130 ——, polished brass, 6 inches square **1.00**

54–131 ——, polished brass, 10 inches in diameter **1.40**

54–132 ——, polished brass, 10 inches square **1.40**

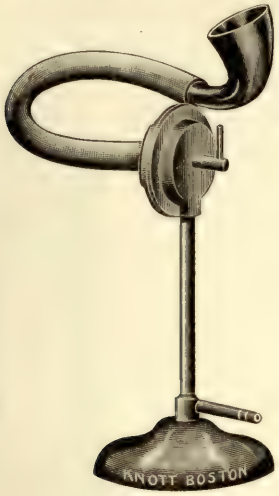
54–142 CHLADNI'S PLATE CLAMP, for use with two sizes of Chladni's Plates up to 10 inches in diameter. Illustrated in No. **54–127** **2.70**

54–145 LYCOPODIUM POWDER, for use in Kundt's Tubes and on Chladni's Plates. Before using this powder, we recommend that it be thoroughly dried for best results. Per four-ounce carton . . . **.45**

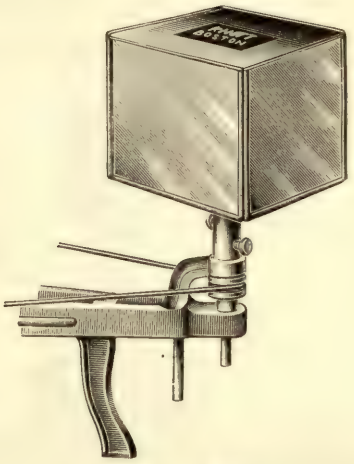
54–147 SAND, for use on Chladni's Plate. This is the best quality fine-grained sand carefully sifted. Per eight-ounce carton . . . . . **.25**

57–20 DOUBLE-BASS BOW, recommended for exciting Chladni's Plates **1.50**

MANOMETRIC FLAME APPARATUS



No. 21–290



No. 21–295

54–165 MANOMETRIC FLAME APPARATUS for analysis of sound.

The apparatus consists of a König's Manometric Flame Capsule and the Cubical Mirror which, in use, must be attached to the socket of a rotator. The Manometric Capsule is constructed of a two-part casting assembled with the sensitive diaphragm between. To one casting is attached the tube and mouth-piece, to the other the jet and gas tube, the latter attached to a base forming the support. The cubical mirror consists of a metal box to the sides of which are fastened mirror plates. To the lower side of this box is attached a spindle to fit the socket of the rotator.

Apparatus complete, as illustrated, but without Rotator **$6.35**

21–290 KÖNIG'S MANOMETRIC FLAME CAPSULE complete, as illustrated above **3.15**

21–295 CUBICAL MIRROR, as used in No. **54–165** **3.20**

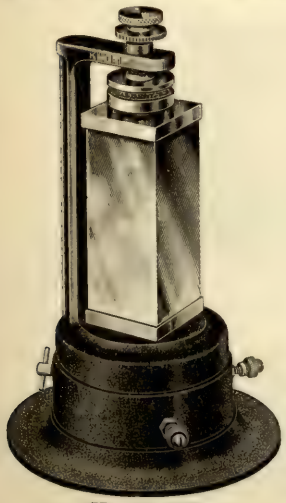
ROTATORS. SECTION 21

54–180 MANOMETRIC FLAME APPARATUS for analysis of sound.

This apparatus is similar to No. **54–165,** but of simpler construction. The revolving mirrors are set in brass frame fitted with spindle for revolving by hand. A simply constructed Manometric Flame Capsule is supplied with rubber tube and mouth-piece.

Manometric Flame Capsule, complete with Mirror **5.00**

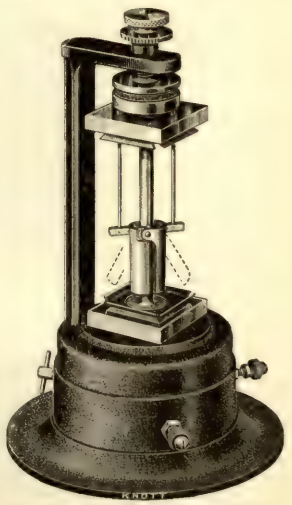
21–300 REVOLVING MIRROR WITH POSITIVE SPEED GOVERNOR. To meet the repeated demands for a mirror which may be revolved at varying speed and of a size sufficiently large for ordinary laboratory work we have, after considerable experimentation, perfected the design illustrated.



No. 21–300

This mirror is self-contained in that the rotating power is contained in the base in the form of a small motor, with " start " and " stop " key. We secure a positive speed, governed by means of a simple, effectively operating device noted above the mirror shaft and a centrifugal governor mounted within the mirror case. We are able to secure with this structure speeds varying from a few revolutions per minute up to 2000, — the maximum speed of the motor. This variation in speed may be made during the revolution of the mirror simply by a movement of the screw over the axle.

As may be noted, this design consists of a metal housing which serves also as a substantial base. Cast to this housing is an upright with projecting arm. The mirror is mounted in metal castings carefully centered. The metal housing is provided with binding posts for connections to the motor and also with " start " and " stop " key. The whole is finished in nickel and black oxidized, presenting a handsome appearance. It will be found efficient for all general work for which a rotating mirror is used **$8.75**



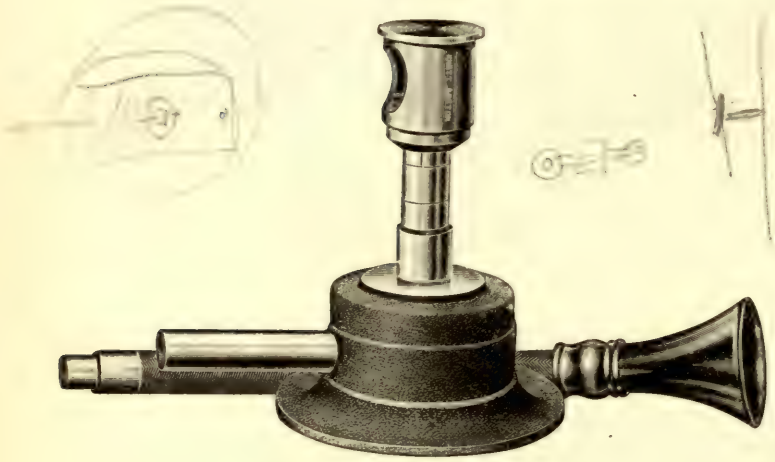
No. 21–300 (Sectional View)

GRAPHIC ANALYSIS OF SOUND WAVES

No. 54–200

"SONOGRAPH"

Invented and Patented by Dr. Herbert G. Dorsey



No. 54–200
Patented Feb. 13, 1912

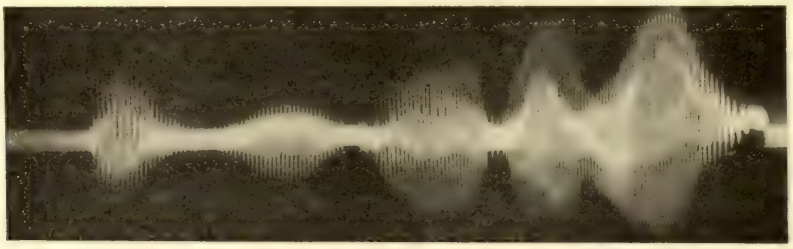
No. 21–300

54–200 "SONOGRAPH." The instrument above illustrated will show in a superior manner all that the manometric flames will show and, in addition, many other interesting experiments. Results are easily obtained. and both simple and complex tones are readily analyzed into their various wave forms, a pure tone depicting in a striking manner the fundamental sine wave.

The operation of the "sonograph" depends on the compression and rarefactions set up in the air by sound — a spoken word, a note from an organ pipe, a tuning fork, etc., etc. These compressions and rarefactions are communicated to a diaphragm which is set in vibration, the vibrations being greatly magnified by a small mirror, the amount of movement being indicated by the tracings of a spot of light on the screen. These tracings will take the form of waves if the spot of light be first directed on a rotating mirror. This rotating mirror should be placed between a lens and the screen. Our No. **21–300**, illustrated above, described in Section **21**, has been especially designed for this work. This speed is ingeniously governed for either very high pitch or very low pitch without stopping the motor which rotates the mirror.

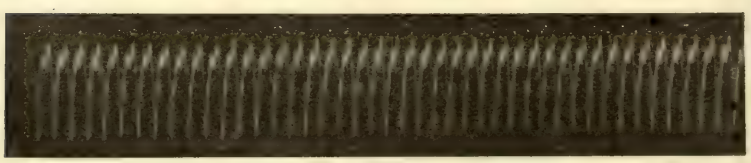
Any source of light may be utilized, — direct rays of sunlight, or from a heliopticon or heliostat, rays from a projection lantern or from any artificial source, be it kerosene, gas lamp, incandescent lamp, etc. With a good arc light or light from the sun, the waves may be easily shown to five hundred students.

The waves illustrated below are photographic reproductions taken on a revolving film.



a e i o u

Wave Forms of Vowels.



Wave Form of Vowel e.

"SONOGRAPH" only, without lens, mirror, etc. **$25.00**

21–300 ELECTRICALLY OPERATED ROTATING MIRROR, designed especially for use with "Sonograph." For description see Section **21** **8.75**

Special Circular on Request

RESONATORS

No. 55–10

55–10 BELL, PLATE, and RESONATOR, for demonstrating that the length of an open cylindrical Resonator must be twice that of one closed for the same tone.

The apparatus consists of a Bell 15 centimeters in diameter and a Chladni's Plate 6 inches square, either of which may be mounted on a stand. The Resonator consists of a brass tube with close-fitting sliding piston. This tube is of sufficient length to respond to the notes emitted by either the Bell or Plate when set in vibration.

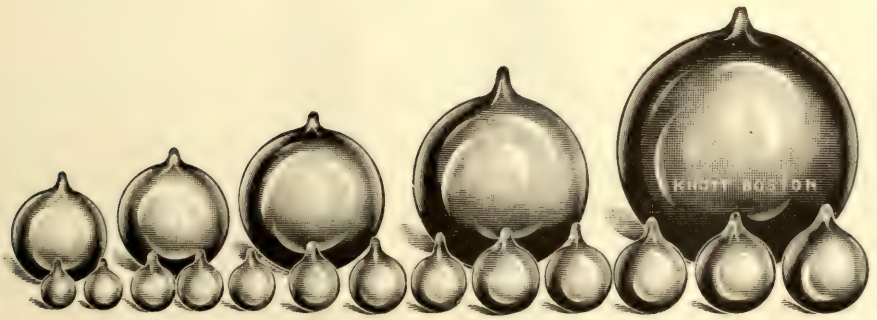
Complete as illustrated, with Bell, Plate, Resonator, and Stand **$4.75**

55–11 STAND, only **1.25**

55–12 SAVART'S BELL, only **1.00**

54–130 CHLADNI'S PLATE, 6 inches square **1.00**

55–14 CYLINDRICAL RESONATOR with adjustable Piston . . **1.50**



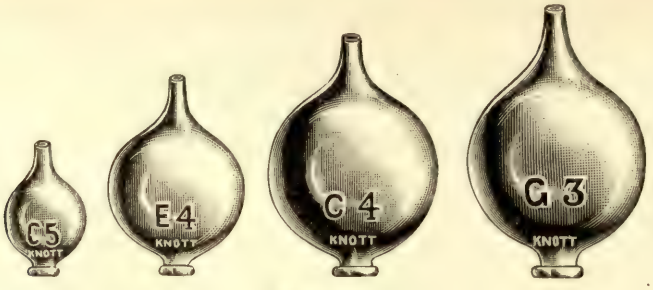
No. 55–32

BRASS HELMHOLTZ RESONATORS. These Resonators are thin brass globes, with wide orifices at one side to receive the exciting waves and narrow orifices to conduct the vibrations to the ear. They are accurately made, neatly polished and lacquered. Fundamental tone, low C = 64 VPS.

55–30 HELMHOLTZ RESONATORS, set of eleven . . . . . Duty Free **$33.25**

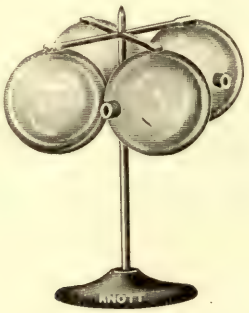
55–32 ——, set of eighteen . . . . . Duty Free **53.75**

55–34 ——, set of twenty-five . . . . . Duty Free **68.00**



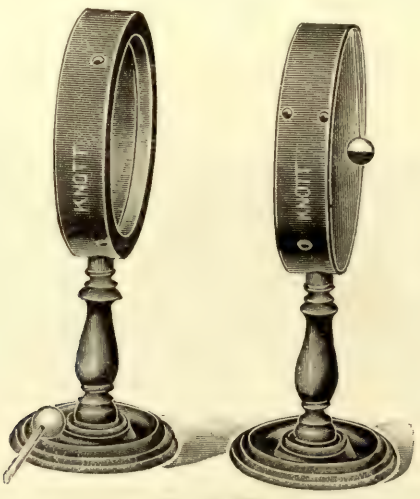
No. 55–45

55–45 **GLASS HELMHOLTZ RESONATORS,** for the analysis of sound, consisting of a set of four glass globes each with a wide orifice at one side to receive the exciting waves and a narrow orifice at the other side to conduct the vibrations to the ear. Will respond to the notes C_5, E_4, C_4, and G_3 . . . **$6.25**



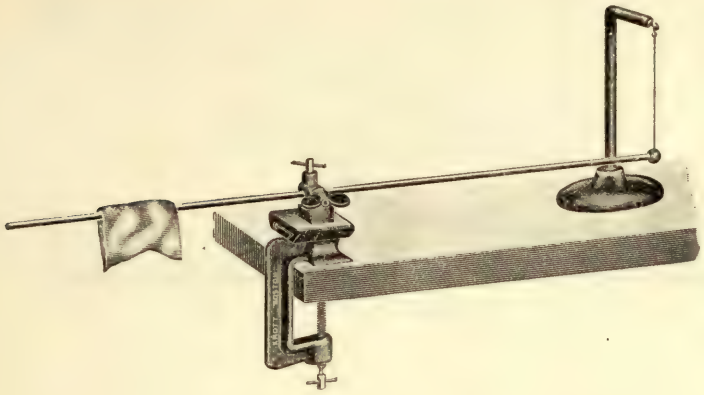
No. 55–60

55–60 **ACOUSTIC REACTION WHEEL,** for illustrating Acoustic Repulsion.
The apparatus consists of four glass resonators fixed upon arms and centered to pivot on a stand. In use, the repulsion is so strong as to produce uniform rotation.
Complete as illustrated **$7.50**



No. 55–70

55–70 **VIBRATION APPARATUS,** for showing that sound propagates rarefactions and condensations in the surrounding media.
This apparatus consists, as illustrated, of two circular discs over one face of which is attached a plate. Suspended so as to rest against the plate of one is a small ball which is used as an indicator of the sound wave. If now the plate of the second is struck a sharp blow by means of the small hammer, vibrations set up will be communicated in waves to the first, causing the small ball to dance.
This is a very striking experiment and can be used to advantage in wave study . . . . . Duty Free **$8.25**



No. 55–75

55–75 VIBRATION OF ROD APPARATUS, for illustrating the vibration of a sounding rod.

The apparatus consists of a centrally clamped brass rod, one end of which is stroked by resinous cloth or set in vibration by other means. Suspended to an upright frame in bi-filar suspension is a light sphere which is adjusted so as to rest against one of the free ends of the rod. Any vibration, therefore, set up in the rod is communicated to the ball, causing it to rebound from the end of the rod.

Apparatus complete as illustrated, without Basic Clamp **$3.00**

No. 55–80

55–80 TREVELYAN'S ROCKER, for illustrating that musical vibrations are maintained by communication of heat.

The apparatus consists of a brass rod with a V-groove milled lengthwise. To this rod is fastened a metal handle with ball end. When this bar is heated at some point below the melting point of lead and placed so that the edges of the V-groove rest on the lead casting as illustrated, the bar begins to rock, emitting a harsh note. This note may be made to rise in pitch by slightly pressing on the bar.

Trevelyan's Rocker with Lead Rest **$2.00**

55–115 TYNDALL'S TUBE, for illustrating the transmission of sound in air by wave motion.

This apparatus consists of a thin metal tube built in sections to three meters in length, the end section terminating cone-shaped. In use this tube is mounted on a simple wooden support. If a lighted candle is placed in front of the conical orifice, and a sharp sound such as that emitted by the clapping together of two sticks is made at the other orifice, the wave motion set up by the sound will be transmitted throughout the whole length of the tube, causing such a disturbance at the conical orifice as to put out the candle flame.

Tube complete with Supports **2.95**

21–280 CROVA'S DISC AND SHIELD, for illustrating the compressions and rarefactions caused among air particles by a sound wave. See Section **21** **2.80**

VELOCITY OF SOUND

KUNDT'S APPARATUS

No. 56–20

56–20 KUNDT'S APPARATUS, for demonstrating vibrations in a tube closed at both ends; also for measuring the velocity of sound in air.

The apparatus consists of a resonance tube, 110 centimeters in length, closed at one end by a tight piston and near the other by a loose-fitting piston at the end of a brass rod. This brass rod, in use, is firmly clamped in a vise. The tight-fitting piston is adjustable within the tube by means of a rod. The whole is compactly mounted on a neat support.

Complete as illustrated **$3.75**

No. 56–30

56–30 KUNDT'S APPARATUS, with fittings for the introduction of various gases for the measurement of the velocity of sound in different gases . . . . . Duty Free **$10.75**

VELOCITY OF SOUND AT 0° C.

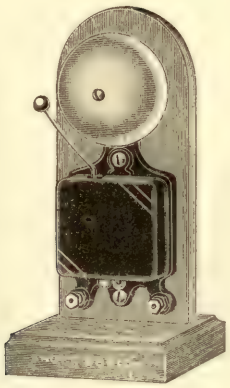
	Meters per second		Meters per second
Air	332	Hydrogen	1269
Aluminum	5104	Iron	5127
Ash, with fiber	4668	Iron at 20°	5130
Beech, with fiber	3340	Lead	1228
Brass	3500	Maple	4106
Caoutchouc	60	Oak	3847
Carbon monoxide	337	Oxygen	317
Carbon dioxide	261	Pine	3322
Cedar	5030	Silver	2607
Chlorine	206	Steel, cast, at 20°	4990
Copper at 20°	3560	Tallow	357
Elm	4120	Tin	2500
Ether	1159	Turpentine at 24°	1212
Fir	4638	Walnut	4601
Gas, illuminating	490	Water at 8°.	1435
Glass	5026	Wax	857
Gold at 20°	1743	Zinc	3700

MISCELLANEOUS SUPPLIES

No. 57–10

57–10 PIANO WIRE, best quality imported, wound in coils, each weighing approximately ¼ pound.

	a	b	c	d
Diameter, inch . .	.028	.022	.0178	.014
Per Coil	**$0.40**	**.40**	**.80**	**1.10**

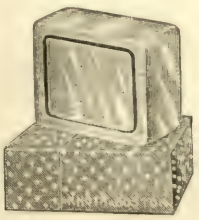


No. 43–290

43–290 MOUNTED ELECTRIC BELL, for use in connection with a bell glass and with our No. **42–15** Air Pump with Electrical Connections, to illustrate non-transmission of sound in a vacuum. Mounted as illustrated on neatly polished wooden upright **$1.60**

No. 57–20

57–20 DOUBLE-BASS BOW, for setting sounding bodies in vibration. This Bow is substantially constructed with a heavy wooden frame. Length 27 inches **$1.50**



No. 57–25

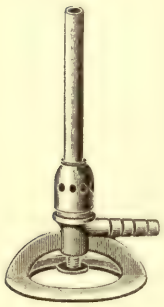
57–25 RESIN for use on bows and rods. Best quality French resin. Per cake, in cardboard box . . . **$0.10**

HEAT

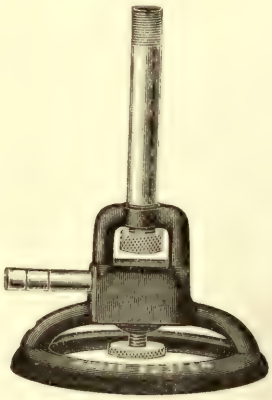
GENERAL APPLIANCES FOR HEAT EXPERIMENTS

BUNSEN BURNERS

Our selection of **BUNSEN BURNERS** from the many designs on the market, has been based upon greatest laboratory utility. Thus, there will be found in this list only burners which have given entire satisfaction and which have shown, from experience, that they are well worthy a place in this edition of our catalog. Each burner is carefully constructed and rigidly tested. The finish is durable, and designed to withstand rough usage and the corrosive action of chemicals in the chemical laboratories. We have given a considerable latitude for choice, and there will be found in this list burners to meet every need.



No. 60–10



No. 60–12

No. 60–17

No. 60–20

60–10 **NORMAL BUNSEN BURNER** for gasolene or illuminating gas, with both gas and air regulation . . **$1.00**

60–12 **HARVARD BUNSEN BURNER** with regulation for both gas and air; tube with threaded top for screwing on of star for holding a chimney, a fine adjustment support . . . . . **.75**

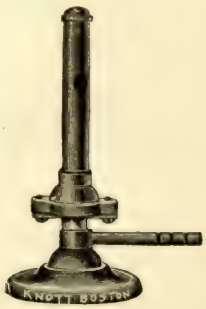
60–17 **PILOT LIGHT BUNSEN BURNER** for gas. Screw regulation for pilot, stop-cock for shut-off, air regulator. Excellent where intermittent flame is required. Tube ½ inch in diameter **2.25**

60–20 **SCHOOL BUNSEN BURNER,** a serviceable gas burner with air regulation; diameter of tube ½ inch . . . . . **.25**

60–23 **CENTRAL DRAFT BURNER** with air regulation . . . . . **.20**

No. 60–27

No. 60–30



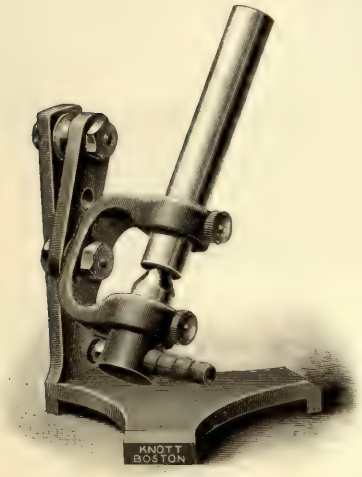
No. 60–35

60–27 **LOW FORM BUNSEN BURNER,** upward curved tube, air regulation, height 3 inches, diameter of tube 7/16 inch **$0.50**

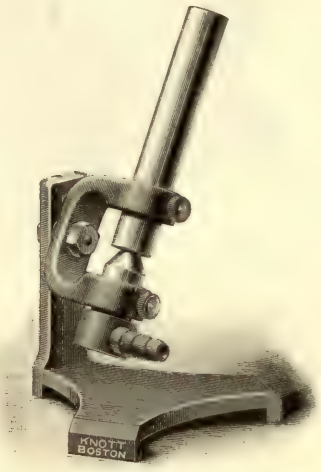
60–30 **GILLEY LOW FORM BUNSEN BURNER,** as regularly used with our Standard Hypsometer No. 60–350 . . . . . **.40**

60–35 **ACETYLENE GAS BUNSEN BURNER,** operating efficiently, giving an intense flame. Diameter of tube 9/16 inch **1.25**

MISCELLANEOUS BURNERS
BLAST LAMPS



No. 60–40

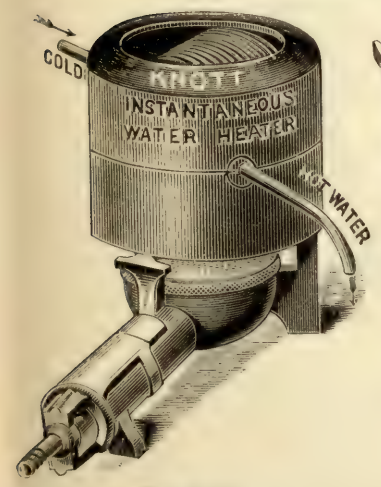


No. 60–45

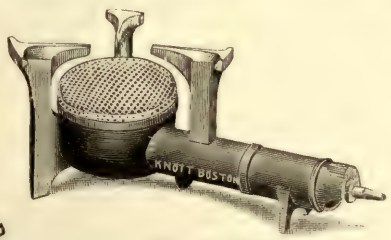
60–40 SEMI-BLAST WYNNE BURNER, supplying either a very hot Bunsen flame or a semi-blast, — in some respects preferable to the ordinary blast flame.
This burner, substantially constructed of brass and iron, has regulations for both gas and air. Perfect combustion is insured. Air adjustment is secured by regulation of height of tube, gas adjustment by a screw. Possibility of adjustment of flame to any position is also a highly appreciated feature of this burner $1.50

60–45 ——, similar to above, but adjustment for flame direction is limited 90

Note. — The general form of this burner has been copied by other houses, who are making it of much lighter material, the adjustments of cheaper construction and with no apparent attempt to reproduce the form of the inner gas chamber which has made this burner so efficient.



No. 60–80



No. 60–75

No. 60–100

No. 60–110

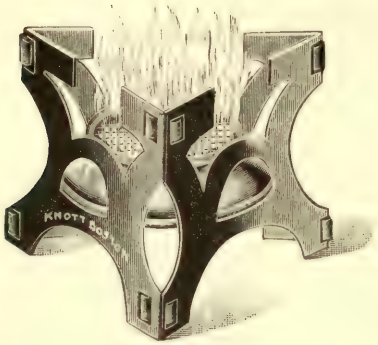
60–75 SOLID BUNSEN FLAME STOVE. The advantage of this burner is a broad flame of uniform temperature. It is especially desirable for heating water in quantities; also for rapid heating of No. **60–365** Hypsometer $2.00

60–80 INSTANTANEOUS HOT WATER HEATER. This apparatus consists of a coiled copper tube enclosed in a Russia iron case. Cold water enters at one end of tube; hot water is delivered at the other end, — instantaneous in action. Illustration pictures apparatus complete with above stove.
Complete with Burner 6.00

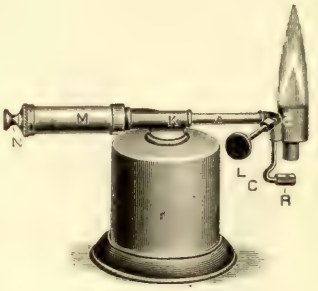
60–81 INSTANTANEOUS HOT WATER HEATER without Burner 4.00

60–100 POLISHED COPPER ALCOHOL BURNER, capacity two ounces.
This is a small, highly appreciated burner giving a very hot flame.
With ground-on cap, wick, and wick-holder 40

60–110 ALCOHOL BURNER, glass, capacity 8 ounces.
Complete with ground-on cap, wick, and wick-holder 38



No. 60–120



No. 60–135

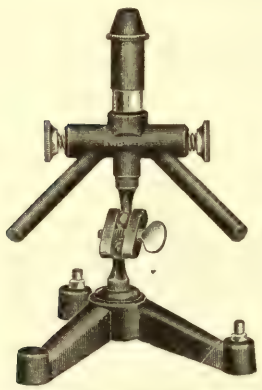
60–120 HOT-BLAST ALCOHOL STOVE. This is a compact stove weighing only 5 ounces. Its efficiency is remarkable. In actual tests water has been heated to boiling point from 0 degree Centigrade in 12½ minutes.

We have no hesitancy in recommending this stove for general use in laboratories not connected with gas.

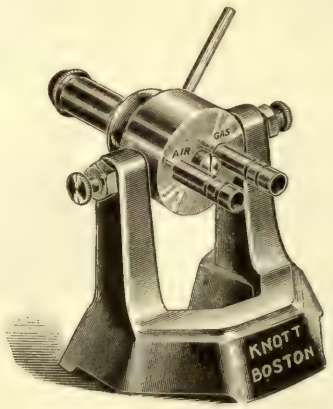
Complete as illustrated, with tripod support **$0.25**

60–121 ——, same as above, without tripod support . . . . . **.18**

60–135 GASOLENE BURNER. This burner meets all the uses of a Bunsen burner. It is practically automatic in its action, generating its own gas. Air pressure is obtained by small force-pump contained in the handle. Flame is adjustable from very small height to 5 or 6 inches, and will burn for 1¼ hours at full blast from one filling of the reservoir, which holds about ½ pint of gasolene and with one pumping of air pressure **3.00**



No. 60–150



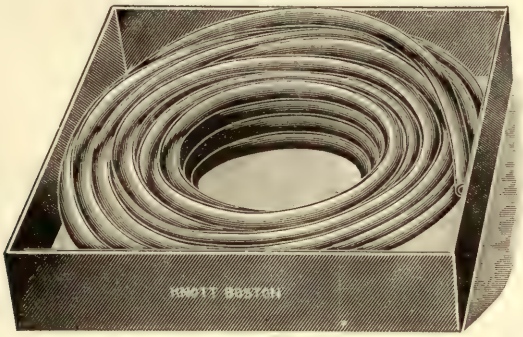
No. 60–160

60–150 BUNSEN BLAST LAMP, stable and durable in construction, capable of the most exacting service. Will produce the maximum intensity of heat with the minimum consumption of gas. Both air and gas pipes supplied with stop-cock **$3.50**

60–160 DOUBLE CONCENTRIC BUNSEN BLAST LAMP, for illuminating gas only.

This type of lamp has an inner air jet and an inner tube which may be used either for air or gas, and an external gas tube. The gas and air are changed automatically from the larger to the smaller tube by a slight movement of the lever at the back, the same movement also adjusting both gas and air to each other for each tube. This combination of practically two blowpipes gives a great range of power from a small-pointed jet to a brisk flame, using approximately 35 feet of gas per hour **10.00**

FOOT BLOWER. See No. **60–275.**

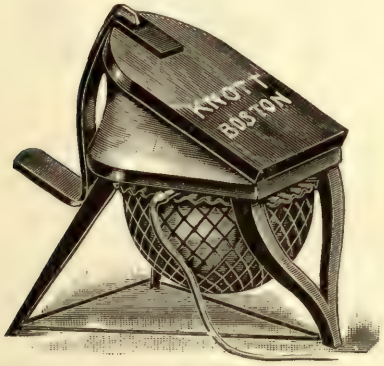


No. 60–250

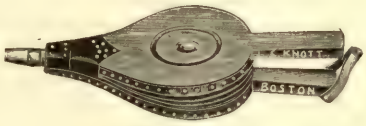
60–200 **BURNER WING TOP** for producing a hot, smoky, wide flame, advisable in bending glass tubing . **$0.15**

60–250 **ANTIMONY RUBBER TUBING** for burner connections. This is the best quality antimony tubing, made from our own formula for the past seventeen years.

	a	b	c
Inside diameter, inch	3/16	1/4	3/8
Per Foot	$0.08	.12	.17



No. 60–275



No. 60–300

60–275 **FOOT BLOWER,** for Blast Lamp, Blowpipe, and similar work.
This is a substantially constructed blower of the latest pattern, with iron legs, producing a steady powerful blast. Diameter of air reservoir, 9 inches; blast pressure per inch, 1½ pounds; cubic feet of air per hour, 330 . . . . . **$8.00**

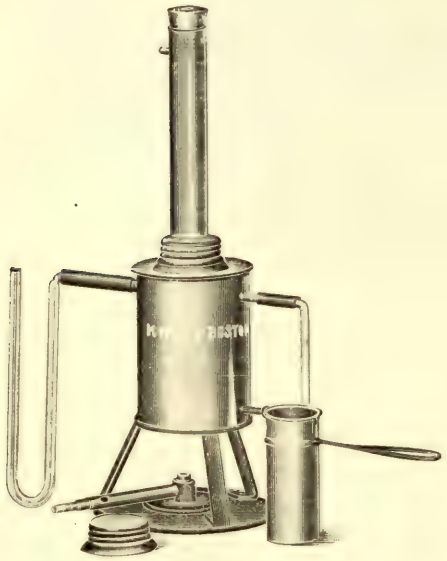
60–300 **HAND BELLOWS.** This is a simple inexpensive blower, width 7 inches, capable of efficient service where a not too powerful blast is required **1.00**

No. 60–325

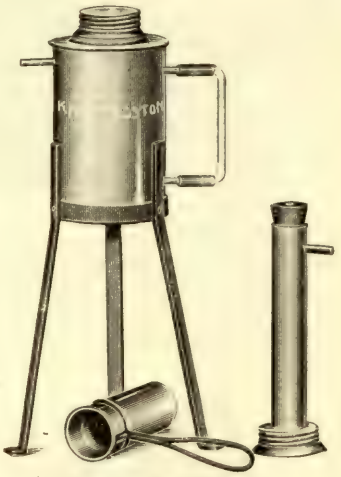
60–325 **POLISHED COPPER BEAKER,** of heavy polished copper, of extreme utility in a great number of experiments requiring the use of an indestructible utensil for boiler, etc. Capacity 500 cubic centimeters **$0.90**

60–330 **POLISHED ALUMINUM BEAKER,** similar to above, 500 cubic centimeters capacity **1.00**

HYPSOMETERS



No. 60–350



No. 60–365

60–350 GILLEY STEAM BOILER or HYPSOMETER for general use in heat, in generation of steam, in determining the boiling point of a thermometer, or for use where steam is required for the proper conduct of an experiment.

The apparatus proper consists of a carefully constructed copper boiler mounted on three legs. This boiler is constructed of best quality of material, all joints being sealed in a manner to obviate the danger of destruction due to careless overheating. Entering the sides of this boiler are three tubes, two of which are connected by rubber tubing and glass for showing the water level, the third for attachment of the pressure gauge. The top of this boiler is provided with a screw to which may be attached the screw cap when it is desired to use the boiler merely as a steam generator. This screw must be replaced, however, by a thermometer tube in using the apparatus in determining or in testing the boiling point of a thermometer. In specific heat experiments, this tube is replaced by the dipper in which the solid is heated.

The apparatus is furnished complete as illustrated without Pressure Gauge or Burner, but including the Steam Boiler, Screw Cap, Thermometer Tube, Dipper, and Water Gauge.

This form of Hypsometer is recommended for its compactness, stability, and rapidity of heating (see special circular provided for it) and ease with which thermometer readings may be made. The tall form of apparatus brings the reading portion of the thermometer scale so high that many students are not able to make accurate readings without the use of a stool or some other means of bringing the eye to the right position. The errors of parallax, almost unavoidable in the use of the tall form, are a serious drawback to its use **$2.25**

60–30 GILLEY LOW FORM BUNSEN BURNER, as illustrated in No. **60–350** above . . . . . **.40**

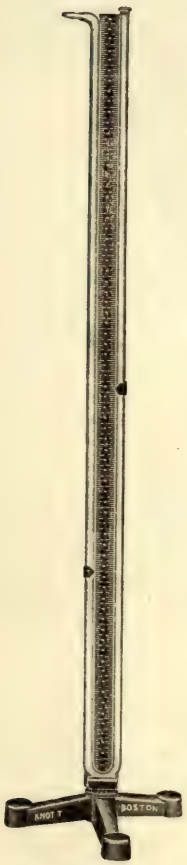
60–100 POLISHED COPPER ALCOHOL BURNER, capacity 2 oz., giving a very hot flame. Advised for use with No. **60–350** when laboratory is not equipped with gas . . . . . **.40**

60–365 STEAM BOILER or HYPSOMETER, as designed by G. M. Turner.

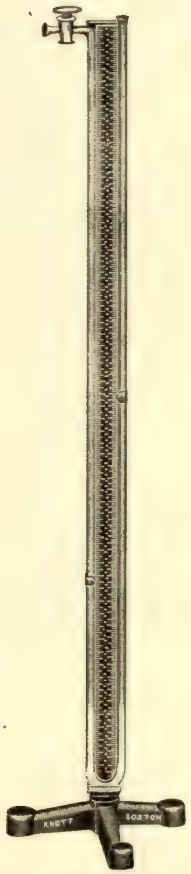
This form of Hypsometer has received the same careful attention in design and details of structure as our No. **60–350**. Its design was first suggested to fill the demand for a hypsometer the steam boiler of which could be detached from the tripod support and which could make use of the ordinary type of Bunsen burner. As may be noted from the illustration, our design fulfils these requirements. This form has the further advantage over our No. **60–350** in that it may be used on a stove similar to our Nos. **60–75** and **60–120**, the stoves in these cases answering the purpose of the tripod support.

Complete as illustrated, with tripod support, steam boiler, screw cap, and thermometer tube . . . **2.50**

PRESSURE GAUGES



No. 43–170



No. 41–113

43–170 **ONE METER PRESSURE GAUGE,** as designed by Messrs. Turner and Hersey.
This gauge has been especially designed for registering high pressures, the length facilitating this use. It must be used, however, on some form of stand. Our illustration shows it in use mounted on our No. **41–116,** Boyle's Law Stand, a description of which will be found under No. **41–115.**
Complete as illustrated, with Stand **$3.20**

43–171 **PRESSURE GAUGE TUBE** only, unmounted **1.35**

41–113 **MILLER'S COMBINATION PRESSURE GAUGE,** for registering high pressures.
This is a tube 1 meter in height which in use should be placed on some form of support. Our illustration shows it mounted on our No. **41–116** Boyle's Law Stand. One arm of this tube is provided with a stop-cock so that it may be used as a Boyle's Law Tube as well as a Barometer. In use as a Barometer the stop-cock is left open until the tube has been filled completely, when it is then closed. The mercury will then fall to the point of barometric height.
Complete as illustrated with Stand **3.85**

41–114 **MILLER'S PRESSURE GAUGE TUBE** only, unmounted **2.00**

60–390 **IMPROVED FORM PRESSURE GAUGE,** especially adapted for use with Hypsometer No. **60–350,** on which instrument it will be found illustrated . . . . . **.30**

No. 60–400

No. 60–430

60–400 **WATER TRAP, IMPROVED DESIGN,** essential in determining the latent heat of steam by preventing any condensed steam passing into the calorimeter.
Our design has been improved by the short curved end which entirely obviates any danger of condensed steam passing through into the calorimeter **$0.35**

60–405 **H-K STEAM TRAP,** consisting of bottle with glass tubes and stopper arranged to catch any condensed steam as it passes through the bottle . . . . . **.45**

60–430 **GALVANIZED IRON ICE TRAY,** designed especially for cooling dry air enclosed in Charles Law Tube. With tubulature as illustrated . . . . . **.75**

60–435 **CANVAS ICE BAG,** for crushing ice into small fragments for calorimetric determinations . . . . . **.22**

RADIATION, REFLECTION, CONDUCTION, CONVECTION, RADIOMETERS

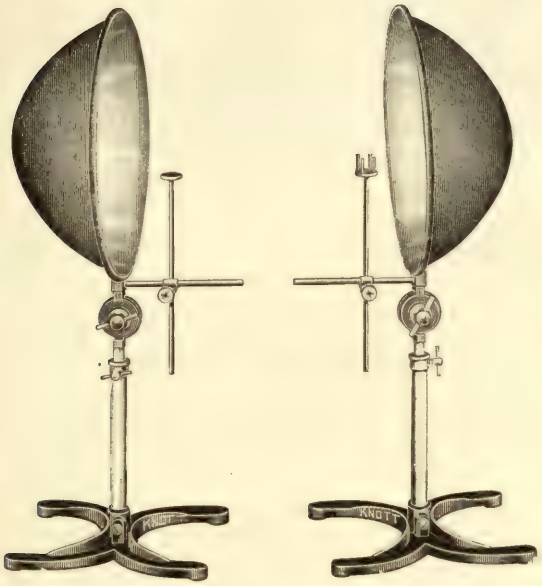
No. 61–10

No. 61–11

61–10 **CROOKE'S RADIOMETER,** illustrating attraction and repulsion arising from radiation.
This instrument consists of a very light vane constructed of thin mica discs fastened at the ends of four arms of aluminum wire, the whole arranged to turn very freely about a vertical axis and enclosed in a glass vessel which is highly exhausted. Each of these mica discs is blackened on one side. On exposing the Radiometer to any source of radiant heat the vane revolves in such a direction that the blackened faces are always receding.
Mounted on glass foot **$1.90**

61–11 **CROOKE'S DOUBLE RADIOMETER,** similar to above, but with two bulbs, in each of which is mounted a vane pivoted independently with its blackened faces opposite to each other.
Mounted on glass foot **4.00**

PARABOLIC REFLECTORS



No. 52–10

52–10 THIRTEEN-INCH UNIVERSALLY ADJUSTABLE TRUE PARABOLIC REFLECTORS, for demonstrating Reflection of Sound, Heat, and Light Waves.

In offering for sale our Improved Reflectors we desire to emphasize the **TRUE PARABOLIC SURFACES.** The curves of these surfaces have been accurately calculated and then by painstaking processes a chuck has been turned to the true parabolic curve. Our Reflectors are all spun from this chuck. The reflecting surface is then highly polished and heavily nickel-plated, presenting an excellent surface without waves.

The Reflectors are mounted in a two-part circular casting in such a manner as to entirely obviate any danger of distorting the surfaces. This two-part casting is brought together at the bottom, where it makes a swivel junction with a rod which telescopes into the supporting base.

The Holders and Attachments are all of special design which allow of both coarse and fine adjustments. We, therefore, secure a tilting movement for the Reflectors, an adjustment for proper height, and universal movements for each attachment.

In demonstrating reflection of heat waves either a candle or a heated metal ball may be used in one of the Carriers at the focus of one reflector; if now a piece of phosphorus be placed at the focus of the other reflector in its Carrier, the heat waves brought to a focus will cause the phosphorus to burn.

The finish of this instrument is fully in keeping with the design. The outer surfaces of the reflectors are dull oxidized, the H-Base japan, and all brass parts polished and nickel-plated.

Thirteen-inch Universally Adjustable True Parabolic Reflectors complete as illustrated with Attachments . . . . . Per Pair **$17.50**

52–15 THIRTEEN-INCH UNIVERSALLY ADJUSTABLE TRUE PARABOLIC REFLECTORS, same as above, mounted on stand but without Attachments or Carriers . . . . . Per Pair **13.50**

ABSORPTION — RADIATION SCREENS

No. 61–70

No. 61–75

61–70 **ABSORPTION SCREEN,** for the comparative illustration of the absorptive power of two different substances.

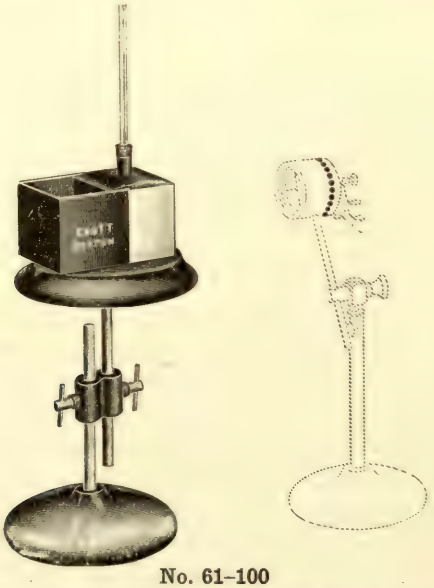
This is a screen of polished metal with ring of black painted on face, and the back coated with red mercuric oxide.

If a source of radiant energy is held in front of the face, a ring will be reproduced in yellow on a red ground on the back of the screen. As the mercuric oxide turns yellow at 150 degrees Centigrade, it may be concluded that a black surface has more absorptive power than a polished surface . . **$3.90**

61–75 **RADIATION SCREENS,** for comparative illustration of the absorptive power of two different substances.

This apparatus consists of a pair of screens, 10 inches square, one of polished metal, the other of metal with the face blackened, each screen with small ledges at the back for pieces of phosphorus.

When placed facing source of radiant energy, it will be noted that the action upon the phosphorus is immediate in the case of the blackened screen, whereas the energy is deflected on the polished screen, demonstrating the absorptive power of a blackened surface and the reflecting power of the polished surface . . . . . Per Pair **4.25**



No. 61–100

61–100 **LESLIE'S CUBE,** for the comparative illustration of the emissive powers of different substances.

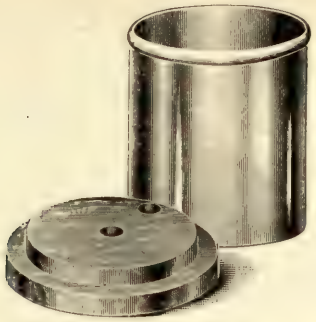
This is a hollow metal cube, 2½ inches on an edge, one face polished, the other three coated with different substances which have different emissive powers. A tubulature is provided at top for introduction of hot water and then, if desired, for a thermometer.

When these surfaces are allowed to radiate in succession against the face of a thermopile or other delicate radiometer, it will be noted that the indications vary, showing the polished metal a very poor radiator, the other substances varying in emissive powers.

Leslie's Cube only, without Thermopile and without Stand, with three-sided protective case . . . **$1.65**

THERMOPILES. For illustration and description see Section **64.**

64–15 **DIFFERENTIAL THERMOMETER,** frequently desired in connection with Leslie's Cube. For illustration and description, see Section **64** **7.50**



No. 61–135

61–135 COOLING CUP, for comparing the rate of cooling of different substances.
The apparatus consists of two cooling cups, one nickel-plated, the other blackened, with two wooden covers each with hole for thermometer.
In use, each is supported in the ring of a Ring Stand on Wooden Support Ring. . Hot water is poured into each and curve of rate of cooling is determined by the reading on the thermometers.
Apparatus complete, with two Cups, one nickel-plated, the other blackened, two Support Rings, and two Covers $1.65

61–136 NICKEL-PLATED COOLING CUP . . . . . Each .50

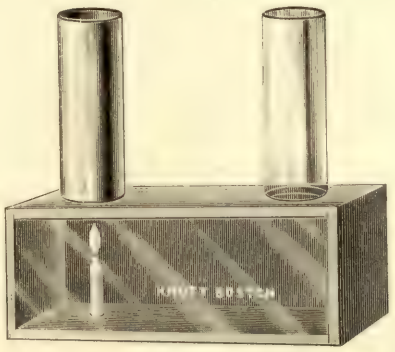
61–137 BLACKENED COOLING CUP . . . . . Each .55

61–138 WOODEN SUPPORT RING . . . . . Each .15

61–139 WOODEN COVER . . . . . Each .15

CONVECTION OF HEAT

No. 61–150



No. 61–160

61–150 CONVECTIONAL CURRENT APPARATUS, for illustrating Convectional Currents in Liquids.
This consists of a closed glass tube, rectangular in shape, with opening at top for introduction of water. When this tube is heated in the lower part, currents are set up. These currents will be readily noted by introduction of a few grains of cork dust or addition of some aniline dye $1.15

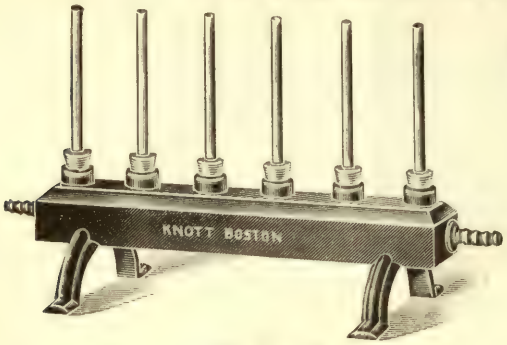
61–160 CONVECTIONAL CURRENT APPARATUS, for illustrating Convectional Currents in Air.
This apparatus consists of a rectangular metal vessel with removable glass front. By placing a burning candle in the box under one of the chimneys, convectional currents are set up as may be demonstrated by use of burning Touch Paper or other smoke producers, at the open end of the other chimney.
Apparatus complete as illustrated, but without candle 1.90

61–161 CHIMNEYS, straight form . . . . . Each .15

70–50b CANDLES, twelves (12 to the pound) . . . . . Per dozen .20

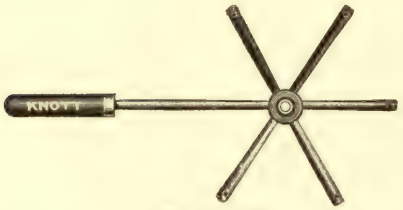
61–163 TOUCH PAPER . . . . . Sheet .10

CONDUCTION OF HEAT



No. 61–175

61–175 HARCOURT VERTICAL CONDUCTOMETER for illustrating relative conductivities of different solids.
This apparatus consists of a cored casting into which steam may be led from some steam generator. (See Hypsometers Nos. **60–350** and **60–365**.) The top of this casting is provided with tuberlatures into which are placed the stoppers holding the different metal rods.
Complete as illustrated with inlet and outlet tube for steam **$3.90**



No. 61–178

No. 61–180

No. 61–185

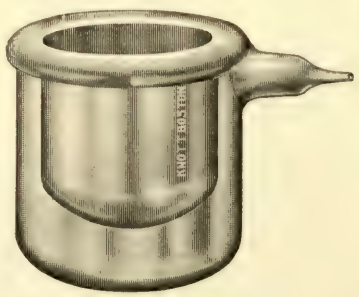
61–178 HEXAGONAL CONDUCTOMETER for illustrating the conductivity of different metals.
This conductometer consists of a hexagonal casting into five faces of which are threaded five rods of different material; into the sixth face is threaded a brass rod terminating in a handle. On each rod at equal distances from the faces are cavities for phosphorus **$1.60**

61–180 PRIMARY CONDUCTOMETER for illustrating conductivity of metals.
This conductometer consists of four rods of different metals fastened to a wooden backing so that all meet conveniently for simultaneous heating . . . . . **.35**

61–183 CONDUCTIVITY RODS, set of three, 8 centimeters long, for introduction into hot water when their relative conductivities may be noted . . . . . **.30**

61–185 COMPOUND ROD for comparative conductivity illustration.
This consists of a rod, 5 inches by ½ inch diameter, part of which is wood, part brass. When heated at middle and held in hand, the relative conductivity may be readily noted . . . . . **.35**

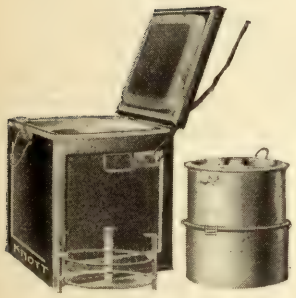
No. 61–200



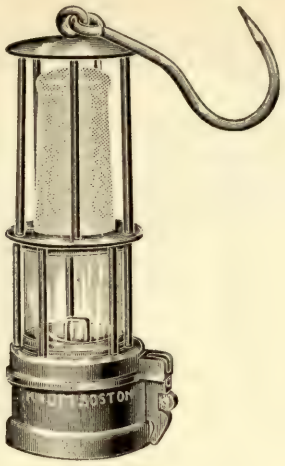
No. 61–205

61–200 DEWAR BULB illustrating the practically non-conductivity of a vacuum; designed for transporting liquid air.
This consists of a double-walled glass vessel, the chamber between walls being exhausted. Capacity 500 c.c. **$3.90**

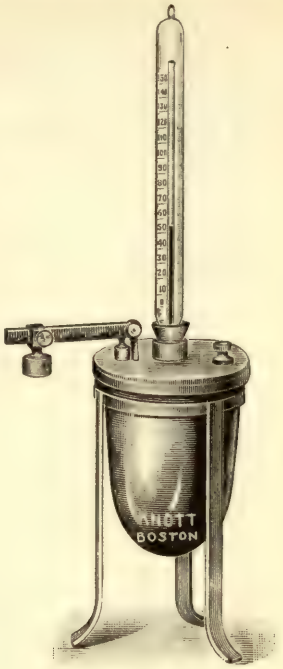
61–205 UNEXHAUSTED DEWAR BEAKER for study of heat insulating qualities of a vacuum chamber.
This apparatus consists of a double-walled vessel with tube entering inner chamber for purpose of exhausting same **3.25**



No. 61-210



No. 61-215



No. 62-10

61–210 FIRELESS COOKER. In Manual Training Schools, Vocational Schools, and schools giving courses for young women the Fireless Cooker has become a prominent and important feature.

It should be the design of every course in Physics to study the scientific aspects of the Fireless Cooker in its relation to questions of conduction, convection, and temperatures, and time required to produce the fundamental chemical changes occurring in the process of cooking.

We are in position to supply the Fireless Cooker of the very best make worked out upon a scientific basis, preliminary heating being secured either by gas or electricity. The electrically operated cooker illustrated will doubtless prove the most satisfactory where the electric current is available. We list only one size, but other sizes will be supplied if desired. This is a convenient size, supplied with two aluminum kettles and one aluminum baking rack.

The case of the cooker is of planished steel, provided with legs and castors. The heating element is below the solid cast bottom of the cooking compartment, and so located that expansion and contraction do not injure it or allow steam and water to cause short circuits.

Complete with aluminum utensils $16.00

61–215 DAVY'S SAFETY LAMP, illustrating the high conductivity of metal gauze. Valuable in mines against "fire damp," in that although an explosive mixture may burn within the gauze, the flame cannot pass through it to the gas outside 2.50

61–220 LIQUID CONDUCTION TUBE, illustrating the slight conduction qualities of water. Water may be boiled in upper part while ice remains unmelted at lower end 15

62–10 PAPIN DIGESTER, illustrating the rise in boiling point by increase in pressure.

This is a strongly constructed brass boiler about 5 inches high by 3½ inches average diameter. With gasket and heavy metal cap, which may be rigidly clamped to boiler. This cap is provided with a hole for thermometer and also with a safety valve.

Complete as illustrated with Safety Valve and Weight, Tripod Support, and Thermometer Duty Free 14.00

62–11 ——, similar to above, but with addition of Pressure Gauge . . . . . Duty Free 17.50

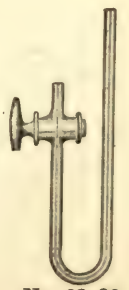
62–15 BOILING POINT OF ALCOHOL TUBE, after Millikan & Gale's "A Laboratory Course in Physics," Exercise 23, for determining the boiling point of alcohol by finding the point at which its saturated vapor pressure is equal to the atmospheric pressure.

This is a simple form of U-Tube, closed at one end. In use it is partially filled with mercury and alcohol carefully worked around into the closed arm from which the air is altogether driven. The alcohol is vaporized by immersion in a hot bath. When vapor pressure equals atmospheric pressure, the mercury will be at the same height in both arms. The temperature of the water bath at this point will be the boiling point of alcohol.

Tube only, unfilled 30

62–20 VAPOR PRESSURE TUBE, for determining vapor pressure and boiling point of a liquid.

This apparatus consists of a U-Tube, one branch of which is provided with stop-cock, an indispensable feature for excluding the air in the closed arm and for the introduction of the liquid; also for the proper cleaning of the tube after use $1.45



No. 62-20

No. 62–50

VAPOR TENSION APPARATUS

62–50 VAPOR TENSION APPARATUS, for direct comparison and measurement of the vapor tensions of different liquids.

The apparatus consists of four heavy-walled glass tubes connected through a stop-cock at the top to a small reservoir. These four tubes are held by a special clamp to a metal upright supported on our H-Base. A second clamp trough casting is provided for mercury into which the open ends of the tubes dip. Each tube has an individual trough of its own, thus avoiding expense of an unnecessary amount of mercury.

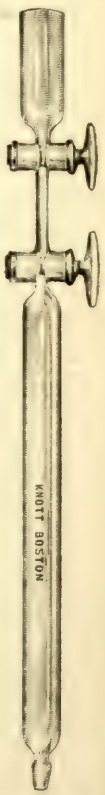
Each tube is filled with mercury and then supported by the clamp with the open end beneath the surface of the mercury in the mercury reservoir. The mercury in the tubes will stand at barometric height. Three of the small reservoirs at the tops of the tubes are now partially filled with the liquids whose vapor tension is to be studied. The fourth reservoir is partially filled with water for comparison of vapor tensions. Equal amounts of the liquids are allowed to enter the tubes by carefully opening the stop-cocks. Necessary factors are obtained by measuring the heights of the mercury above the surface of the mercury in the reservoir.

Complete as illustrated with four tubes **$8.75**

62–51 VAPOR TENSION TUBES, as used in above . . . . . Each **1.50**

62–53 VAPOR TENSION APPARATUS, similar to above, but tubes not provided with stop-cocks. Each tube is heavy walled with closed end. Complete with four tubes, supporting upright, clamp, and mercury reservoir **4.85**

62–54 VAPOR TENSION TUBES, as used in above . . . . . Each **.45**



No. 62–62

62–60 VAPOR TENSION APPARATUS, for accurate determination of the vapor tension of a liquid.

The apparatus consists of the illustrated tube No. **62–62** with cup and two stop-cocks, between which is a capillary of known volume. This tube is adjustably mounted in place of the air thermometer bulbs as illustrated under No. **64–55**. (See illustration and description.)

In use, mercury is allowed to fill the tube completely to the top stop-cock. This stop-cock is now closed and the cup is filled with liquid whose vapor pressure is to be determined. Mercury is lowered in the tube to a point below the lower stop-cock, when this cock is closed, leaving a partial vacuum between the two stop-cocks. The upper stop-cock is now opened, allowing the liquid in the cup to fill the capillary. The upper stop-cock is then closed and the lower opened, allowing a known quantity of the liquid to enter the tube. The vapor tension can be determined by the ordinary method.

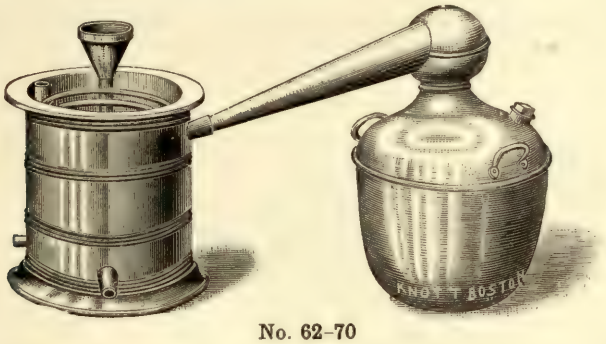
Stand complete as illustrated under No. **64–55** with Air Thermometer Bulb and with the illustrated Vapor Tension Tube No. **62–62** **$12.50**

62–61 STAND complete, without air thermometer, but with illustrated Vapor Tension Tube attached in its place **10.75**

62–62 VAPOR TENSION TUBE only **3.00**

64–57 AIR THERMOMETER BULB **1.75**

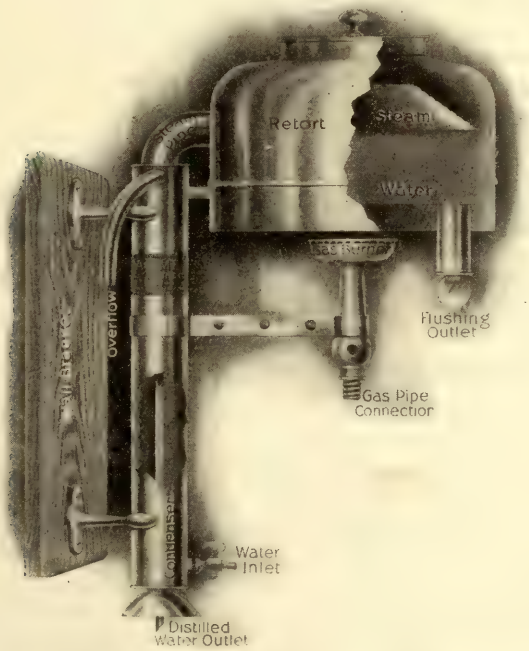
VAPORIZATION, BOILING, DISTILLING, FREEZING, STILLS



No. 62–70

62–70 STILL, for distillation of water or spirits.
This apparatus consists of a heavy tin-lined copper boiler with movable head, connected with the pure block tin condensing worm enclosed in a zinc vessel, provided with proper inlets and outlets. Complete as illustrated.

	a	b	c	d	e
Capacity, gallons . . .	½	1	2	3	5
Each	$8.00	10.00	12.50	15.00	19.75



No. 62–80

62–80 ACME WATER STILL. This still is a perfect apparatus for the production of pure water by distillation. The distillate is cold, and aerated if desired. The apparatus is of first-class workmanship throughout and is made of copper and brass, tin-lined and nickel-plated. The gas and water connections are extremely simple. The Acme Water Still runs automatically and there is nothing to get out of order. It is started and stopped in a moment. The " Acme " is comparatively the fastest and most economical Water Still, as it produces a gallon of distilled water in about 1½ hours, at a cost of about 1½ cents per gallon. It is the most durable still, and will practically last a lifetime, as the mineral and other matter that remains in the retort is drained off through the flushing outlet, this being done in a moment without any trouble and without displacing the still or taking it to pieces. The combustion of gas with our special burner is perfect and all the heat is fully utilized. Wall space required 4 × 12 inches, extreme width 8 inches, projection 14 inches.
Still as illustrated with burner for coal or water gas, natural gas, or acetylene **$22.00**

62–90 **WOODEN HEAT SHIELD,** for use as insulator of heat when it is desired to shield part of an experiment from heat rays emitted from another part, especially when in calorimetry it is desired to use a steam boiler.

The shield consists of a board, mounted upright on a base. This board is provided with hole for passage of delivery tube for the steam generated in the boiler **$0.45**

No. 60–400

60–400 **WATER TRAP, IMPROVED DESIGN,** essential in determining the latent heat of steam by preventing any condensed steam passing into the calorimeter.

This, our design, has been improved by the short curved end which entirely obviates any danger of condensed steam passing through into the calorimeter **$0.35**

60–405 **H-K STEAM TRAP,** consisting of a small bottle with glass tubes and stopper arranged to catch any condensed steam as it passes through the bottle . . . . . **.45**

No. 62–120

62–120 **LIEBIG'S METAL CONDENSER,** for the distillation of liquids.

This condenser is made of brass and highly polished. Length 30 inches; diameter 1⅞ inches. This form prevents breakage **$2.75**

62–125 **LIEBIG'S CONDENSER,** entirely of glass, condensing tube fitted to jacket by rubber connection. Length 12 inches . . . . . **.85**

62–126 ——, same as above, but 24 inches long **1.35**

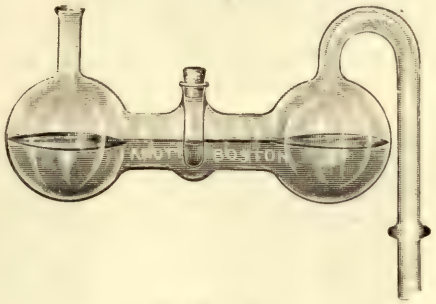
No. 62–140

62–140 **FRANKLIN'S PALM or PULSE GLASS,** for illustrating influence of pressure on boiling.

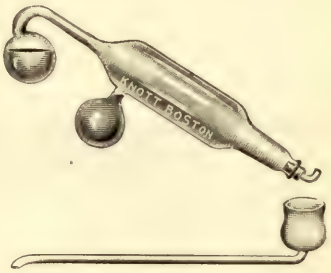
This glass consists of two bulbs joined by a tube which is filled with a colored liquid and from which air has been expelled as completely as possible by boiling the liquid before sealing the tube. There is then in the glass a pressure due to the elastic force of the aqueous vapor which at ordinary temperature is very small. If, now, one of the bulbs be held in the hand, the heat is sufficient to produce a pressure which drives the liquid into the other bulb and causes it to boil violently, the hand feeling also a sensation of cold **$0.45**

CRYOPHORUS

No. 62–150



No. 62–155



No. 62–160

62–150 WOLLASTON CRYOPHORUS, illustrating freezing by evaporation.

The apparatus consists of a bent glass tube, with a bulb at each end. Water is introduced and boiled to expel air, when tube is hermetically sealed, so that it contains, when cool, only water and water vapor.

In use, the water is introduced into the bulb on the bent neck and the other bulb is placed in a freezing mixture. The vapor then is condensed in the tube, causing the water in the bulb to evaporate rapidly in order to yield more vapor. This rapid evaporation causes the water in the bulb to freeze. Without jar **$1.40**

62–155 CARRE'S FREEZING APPARATUS for connecting to an Air Pump, illustrating freezing of water by its own rapid evaporation, at the same time causing ether to boil.

The apparatus consists of two bulbs which, in use, contain sulphuric acid, sufficient to half-fill the connecting tube. One bulb has a neck into which the delivery tube from a flask containing water to be frozen is fitted by means of a cork. A goose-neck tube, the end of which is connected to an Air Pump enters the other bulb. — A small test-tube for ether is sealed in the central part of the apparatus.

A few strokes of the piston of the Air Pump cause the water in the flask to evaporate rapidly. The vapor is absorbed at once by the sulphuric acid, causing more rapid evaporation of the water, at the same time increasing its own temperature to such an extent as to cause the ether to boil, and if the tube containing the ether has been lightly stoppered, causing the cork to fly out **2.50**

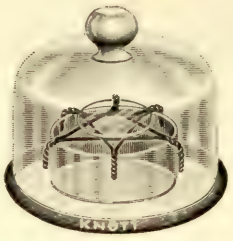
62–160 SULPHURIC ACID CRYOPHORUS, for freezing water by its own rapid evaporation.

The apparatus consists of a glass vessel with two bulbs as illustrated, the lower end of the vessel being drawn out to form a neck which may be stoppered by a stopper plug of glass. A bent thistle-end delivery tube is furnished for the introduction of acid and water to their respective bulbs.

When the top bulb has been half filled with water and the middle bulb filled with strong sulphuric acid, the vessel should be clamped in a position as shown in the illustration. The water is then heated until about ⅛ has been driven off in steam. The lower neck is then tightly corked by means of a stopper plug covered with a piece of india rubber tubing, and the burner is removed.

The water is then cooled by immersing in a cold bath. When sufficiently cooled, the apparatus is turned round a number of times, in such a way that the acid can run in and out of the middle bulb while the water is not allowed to leave the top bulb. The heat generated by the absorption of water vapor drives out any air which may be dissolved in the acid. The stopper is removed and the boiling is continued as described above. After passing the acid several times to and from the middle bulb, the water in the top bulb will be found to solidify. Care must be taken, however, throughout the experiment to prevent any acid passing over into the water bulb, or the experiment will not be a success.

Cryophorus complete as illustrated with Stopper Plug and Delivery Tube **3.65**



No. 43–310

43–310 **FREEZING APPARATUS,** illustrating the freezing of water by the rapid evaporization of ether.
The apparatus consists of a bell glass under which is placed a shallow dish to contain ether. Triangles supporting a watch glass with water rest on the edge of the dish.
As air is exhausted from bell glass, the ether evaporates very rapidly, causing water in watch glass to freeze.
Complete as illustrated $1.40

No. 62–200

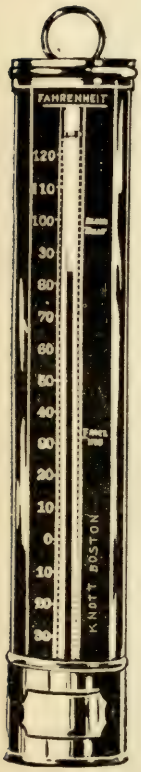
62–200 **DEW POINT APPARATUS,** after Millikan & Gale's "A Laboratory Course in Physics," Experiment 11, for determining the temperature at which water vapor begins to condense out of the atmosphere as the temperature is lowered.
The apparatus consists of a polished metal tube closed by rubber stopper with three holes, one of which contains the delivery tube for connection to the air bulb, the other for the bulb pipette, and the other for the thermometer.
In use, the metal tube is filled two-thirds full with ether. Air is forced very gently through this ether by means of the bulb. This process facilitates cooling, since it increases the evaporating surface. The temperature existing within the tube when the first cloudiness begins to appear upon the polished surface is the Dew Point.
Complete as illustrated $1.22

62–225 **MELTING POINT TUBE,** after Turner and Hersey, for determining the melting point of paraffine, wax, and other substances which, when in solid state, have a color but which turn colorless in liquid state.
This tube consists of a glass tube with end bent and drawn to a point. While hot, the substance is drawn into the tapered point It is now allowed to cool. It is then immersed into water, the temperature of which is gradually increased until the substance loses color, when temperature is noted by thermometer. This reading will be the melting point of the substance 15

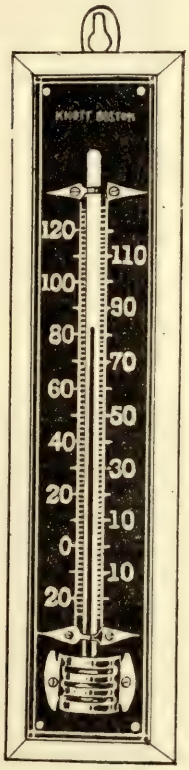
No. 62–240

62–240 **CUBICAL EXPANSION BULB,** for determining the point of maximum density of water.
This apparatus consists of a bulb of known volume with graduated capillary neck.
When filled with water, sufficient to fill the bulb and three quarters of the graduated neck, the bulb is immersed in water, the temperature of which is taken. Freezing mixture is added to bath and continuous readings of thermometer and graduated neck are taken. A point will soon be reached where the reading on the neck does not descend as the temperature decreases but at this point will begin to rise, showing that this is the point of maximum density. This point will be found at about 4 degrees Centigrade 2 00

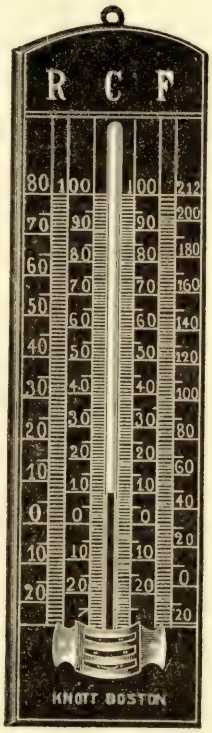
MEASUREMENT OF INTENSITY OF HEAT
THERMOMETERS



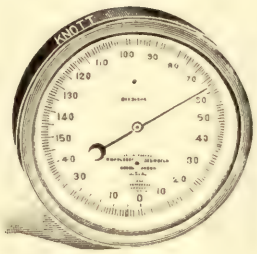
No. 63–10



No. 63–12



No. 63–15



No. 63–18

No. 63–20

63–10 HOUSEHOLD THERMOMETER, 8 inches long, heavy metal frame, reading from –30 degrees to 120 degrees Fahrenheit $0.55

63–12 HOUSEHOLD THERMOMETER, 10 inches long, silvered scale on hardwood back, reading from –30 degrees to 120 degrees Fahrenheit 85

63–15 COMPARATIVE THERMOMETER, three Scale, Fahrenheit, Centigrade, and Reaumur. This is a thermometer, 10 inches long, designed to give the student an instrument which will give a reading in all three scales, thus showing direct comparisons. Made of boxwood, piano rubbed finish, all graduations and letterings distinct. Bulb protected by metal covering 80

63–18 METALLIC THERMOMETER, DEMONSTRATION FORM, with glass back, entire mechanism visible. Diameter 6 inches. This thermometer will be of great pedagogic value in that it shows at a glance the method of multiplying the movement made by two metals soldered together. Range from 50 degrees below to 150 degrees Fahrenheit 4.40

63–20 GROUND GLASS UNGRADUATED THERMOMETER, 13 inches long, half its circumference etched through its entire length. In calling attention to this thermometer, we request that it be not confused with those on the market. With this thermometer, a student can find and mark in pencil on the etched portion both its zero and boiling points. When these are obtained, it will require very little skill on his part to make a complete thermometer. The etched portion obviates the disagreeable features of rubber bands and other indicators . . . . . Per Dozen 6.00

CHEMICAL THERMOMETERS

No. 63–30

No. 63–37

No. 63–50

No. 63–60

No. 63–70

63–25 **CHEMICAL THERMOMETER,** paper scale, 8 inches long, with scale reading from –10 to 100° Centigrade, enclosed in case $0.40

63–26 ——, paper scale, 8 inches long, with scale reading from 0 to 220° Fahrenheit, enclosed in case 40

63–30 **CHEMICAL THERMOMETER,** paper scale, 13 inches long, with scale reading from –10 to 110° Centigrade, enclosed in case 60

63–32 ——, paper scale, 13 inches long, with scale reading from –10 to 210° Centigrade, enclosed in case 95

63–35 ——, paper scale, 13 inches long, with scale reading from 15 to 220° Fahrenheit, enclosed in case 60

63–36 ——, paper scale, 13 inches long, with scale reading from 15 to 400° Fahrenheit, enclosed in case 95

63–37 **CHEMICAL THERMOMETER,** paper scale, 13 inches long, with **double scale** reading from –10 to 110° C. and with equivalent Fahrenheit scale to 220°.
Enclosed in case 90

63–38 ——, paper scale, 13 inches long, with **double scale** reading from –10 to 210° C. and with equivalent Fahrenheit scale to 400°.
Enclosed in case 1.35

63–50 **CHEMICAL THERMOMETER,** stem scale, white enameled back, 13 inches long, graduated from –10 to 110° C.
Enclosed in wooden case 1.00

63–52 ——, stem scale, white enameled back, 13 inches long, graduated from –10 to 210° C.
Enclosed in wooden case 1.15

63–55 **CHEMICAL THERMOMETER,** stem scale, white enameled back, 14 inches long, graduated from −10 to 360° Centigrade, enclosed in wooden case **$1.50**

63–57 ——, stem scale, white enameled back, 14 inches long, graduated from 15 to 600° Fahrenheit, enclosed in wooden case **1.50**

63–6 ——, stem scale, white enameled back, 14 inches long, **double graduations,** from −10 to 110° Centigrade and with equivalent Fahrenheit scale to 220°, enclosed in wooden case **1.50**

63–62 ——, stem scale, white enameled back, 14 inches long, **double graduations,** from −10 to 210° Centigrade and with equivalent Fahrenheit scale to 400°, enclosed in wooden case **1.75**

63–64 ——, stem scale, white enameled back, 14 inches long, **double graduations,** from −10 to 360° Centigrade, with equivalent Fahrenheit scale to 600°, enclosed in wooden case **2.00**

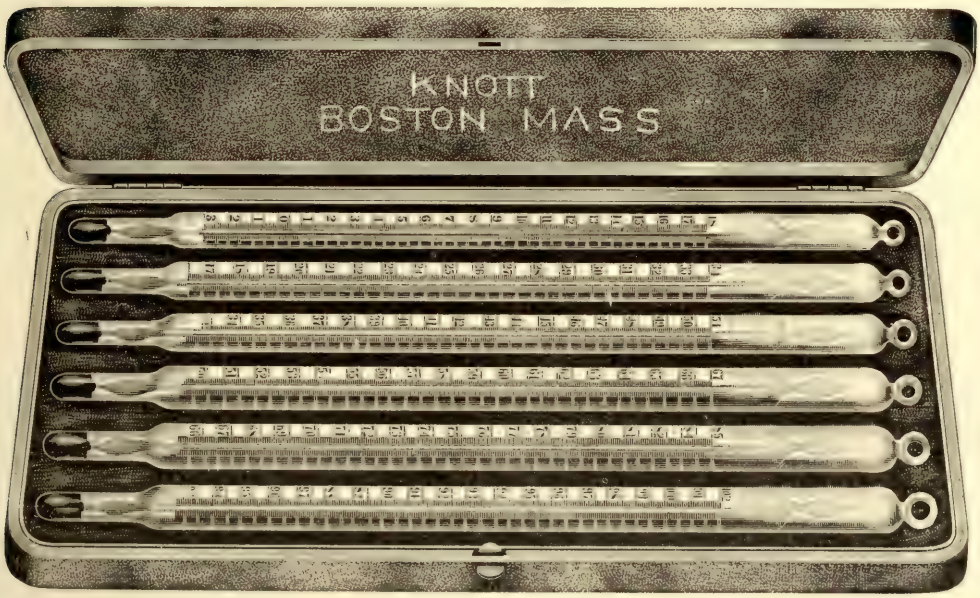
63–70 **CHEMICAL THERMOMETER,** enclosed milk glass scale, 13 inches long, graduated from −10 to 110° Centigrade, enclosed in wooden case **1.00**

63–72 ——, enclosed milk glass scale, 13 inches long, graduated from −10 to 250° Centigrade, enclosed in wooden case **1.25**

STANDARD THERMOMETERS

63–80 **STANDARD CHEMICAL THERMOMETER,** scale engraved on the stem, white enameled back, 16 inches long, graduated from 0 to 100° Centigrade by ⅕ degrees, enclosed in wooden case **3.00**

63–85 **STANDARD CHEMICAL THERMOMETER,** scale engraved on the stem, white enameled back, 25 inches long, graduated from 0 to 100° Centigrade by 1/10 degrees, enclosed in wooden case . . . **3.50**



No. 63–145

63–125 **STANDARD THERMOMETERS,** Centigrade scale, engraved stem, each with zero and boiling point. Set of four as follows, enclosed in fine leather case:

0 to 100° × 1/10 — 100 to 200° × 1/10
200 to 300° × ⅛ — 300 to 400° × ½

Duty Free **$19.80**

63–135 **STANDARD THERMOMETERS,** Centigrade scale, after Allihn, enclosed pearl glass scale, set of three about 12 × ¼ inch, each with zero and boiling point, divided to ½ degrees. Set as follows:

−15 to 100° — 100 to 200° — 200 to 300°

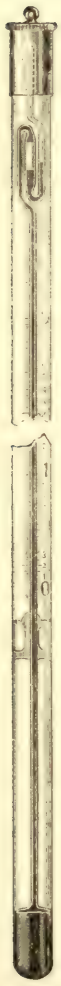
In fine leather case, Duty Free **13.50**

63–145 **STANDARD THERMOMETERS,** Centigrade scale, after Anschuetz, enclosed pearl glass scale, about 4 to 6 inches long by ¼ inch diameter. Set of seven by ⅕ degrees as follows:

10 to 60° — 40 to 110° — 90 to 160° — 150 to 220° — 200 to 270° — 250 to 310° — 300 to 360°

In fine leather case, Duty Free **14.75**

MISCELLANEOUS STANDARD THERMOMETERS



63–155 BECKMANN'S NORMAL DIFFERENTIAL THERMOMETERS, for boiling or freezing point methods in molecular weight determinations, etc.

	a	b	c	d	e
Range, Degrees C. .	1	5 to 6	10 to 12	25 to 30	50 to 60
Divided, degree . .	1/500	1/100	1/50	1/20	1/10
Each, Duty Free .	$9.80	6.50	6.50	6.25	6.25

63–165 CALOMETRIC THERMOMETER, about 20 inches long, scale engraved on pearl glass, from 15 to 25 degrees Centigrade by 1/100 degree . . Duty Free **$7.25**

63–170 HYPSOMETER THERMOMETER, scale etched on stem, length about 14 inches, 90 to 102° Centigrade by 1/10 degree, with zero and boiling points Duty Free **6.00**

63–172 ——, same as above, 95 to 102° by 1/20 degree . . . . . Duty Free **7.75**

63–180 HIGH TEMPERATURE THERMOMETER, Centigrade scale, about 12 to 14 inches long, in the following ranges by single degrees:
0 to 130° 100 to 300° 200 to 540°
Per set of three, in fine leather case. Duty Free **19.50**

63–182 ——, same as above, but with certificate of accuracy from Physik-Technische Reichsanstalt in Charlottenburg . . . . . Duty Free **27.50**

63–190 LOW TEMPERATURE THERMOMETER, stem graduation by single degrees, from –50 to 50° Centigrade; without certificate . . . Duty Free **6.25**

63–191 ——, same as above, with certificate from Physik-Technische Reichsanstalt Duty Free **9.75**

63–193 LOW TEMPERATURE THERMOMETER, stem graduation by single degrees, from –100 to 10° Centigrade; without certificate . . . Duty Free **7.25**

63–194 ——, same as above, with certificate from Physik-Technische Reichsanstalt Duty Free **12.50**

63–196 LOW TEMPERATURE THERMOMETER, stem graduations by single degrees, from –200 to 10° Centigrade, for measuring the temperature of liquid air; without certificate . . . . . Duty Free **13.25**

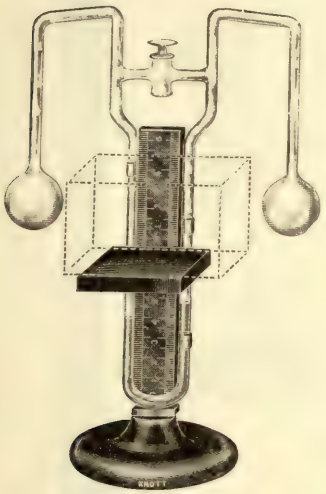
63–197 ——, same as above, with certificate from Physik-Technische Reichsanstalt Duty Free **16.50**

No. 63–155b

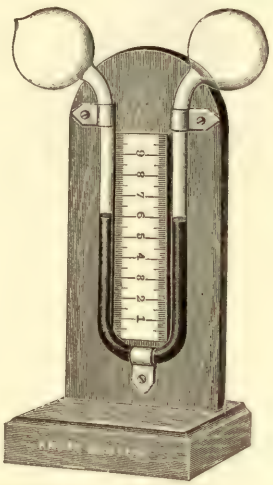
No. 63–155a

SPECIAL THERMOMETRIC INSTRUMENTS

DIFFERENTIAL THERMOSCOPES



No. 64–15



No. 64–20

64–15 UNIVERSAL AIR AND LIQUID DIFFERENTIAL THERMOSCOPE. This design, a modification according to our specifications, may be used equally well for indicating the temperature of liquids, as in comparing temperature of two neighboring places. Thus, as may be noted from our illustration, the thermoscope bulbs are bent downward yet opposite the small table which is designed especially for holding the source of radiant energy. The illustration shows our No. **61–100** Leslie's Cube in position, and comparison of liquids may be demonstrated by use of two vessels containing the liquid, the bulbs dipping into the vessels. The bent U-tube contains the colored liquid, and in a tube which connects the two limbs is a stop-cock by which the liquid in each limb is easily brought to the same level. This glass part is mounted in a frame with a scale, the whole mounted on a neat base.

Without the illustrated Leslie's Cube $7.50

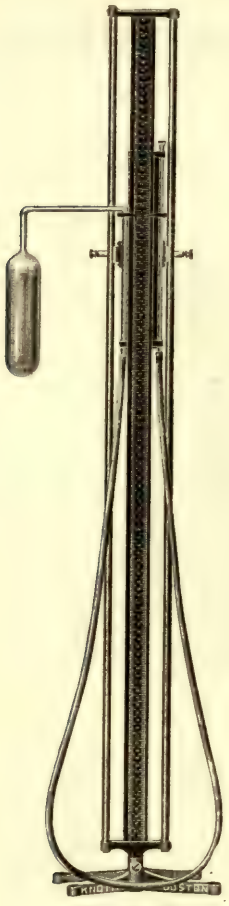
64–20 DIFFERENTIAL THERMOSCOPE, for indicating a difference of temperature between two bulbs. The apparatus consists of two bulbs connected by a U-tube, from which air has been expelled by boiling, before sealing, the liquid contained therein as an indicator. This tube with attached bulb is mounted with scale on an upright support 2.25

No. 64–30

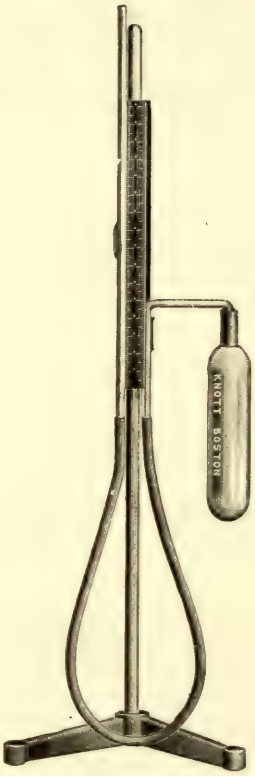
64–30 AIR THERMOMETER, after Rendtorff, for showing expansion of air by heat. This thermometer consists of a bulb into which is sealed a capillary tube, the end of which tube extends nearly to the bottom of the bulb. Through the bulb and sealed into the opposite walls is a wire of high resistivity. Terminals are left outside the bulb for connection to battery. The whole apparatus is freed from air, before sealing, by boiling the colored liquid contained therein 2.25

64–35 AIR THERMOMETER, for illustrating gas expansion, of glass, with two-inch bulb 22

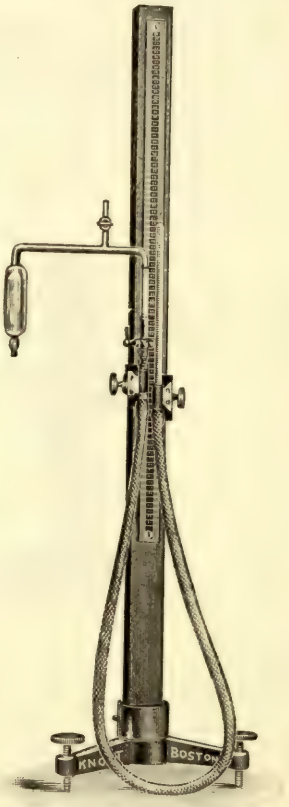
AIR THERMOMETERS



No. 64–55



No. 64–65



No. 64–70

64–55 CONSTANT VOLUME AIR THERMOMETER, for determining the coefficient of expansion of air, or of a gas.

This apparatus consists of a rectangular frame with the scale mounted on one of our H-bases. The air thermometer, fastened by a protective strip of wood, is adjustably clamped to one rod and the open leveling tube similarly mounted and clamped to the other rod. The lower open ends of each are connected by the finest quality of flexible rubber tubing.

This instrument is substantially constructed throughout and handsomely finished in nickel-plate and japan. It has been designed that laboratories may have at a reasonable cost an instrument capable of accurate determinations. We have no hesitancy in recommending it as capable of results attained by instruments of double the cost.

Complete as illustrated **$8.50**

64–57 AIR THERMOMETER BULB, for attachment to above stand to replace breakage **1.75**

64–59 BOYLE'S LAW TUBE, for use on above stand in determining Boyle's Law. This tube may be mounted in place of the air thermometer pictured in above illustration. For apparatus complete see No. 41–110 . . . . . **1.25**

64–65 AIR THERMOMETER, after Millikan & Gale's " A Laboratory Course in Physics," Experiment 13, for determining the coefficient of expansion of air.

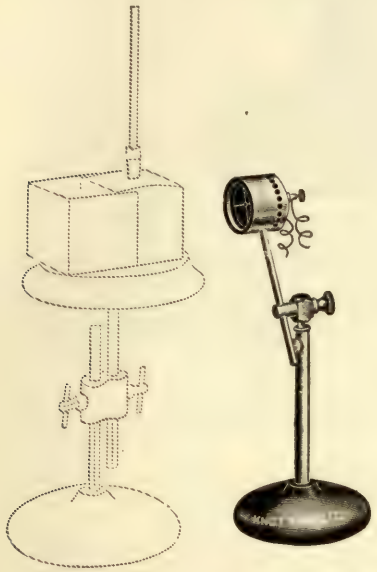
This is an elementary air thermometer, capable of a fair degree of accuracy. It consists of an air thermometer tube, leveling tube, and scale mounted to a backing which may be adjusted along the rod of the tripod stand by means of a clamp attached to the backing. The lower open ends of the tubes are connected by our finest quality flexible antimony rubber tubing. The apparatus is durably finished, the metal parts in bright nickel and japan.

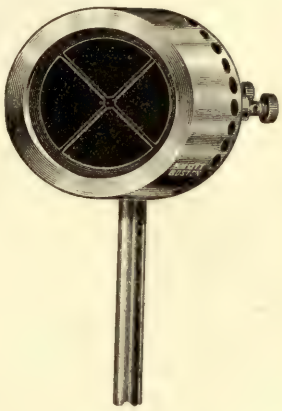
Complete as illustrated **3.30**

64–67 AIR THERMOMETER BULB, as used in above apparatus . . . . . Each **.45**

64–70 CONSTANT VOLUME AIR THERMOMETER, highest quality constructed by one of the most prominent European manufacturers and extensively used as a precision instrument . . Duty Free **35.00**

AN IMPROVED MINERALITE THERMOPILE





Nos. 64–100 to 64–110

We offer in this series of Thermopiles, instruments of two sizes which cover all ranges in both amperage and voltage, of the Bismuth Antimony type, from the single pair to 120 pair.

A study of the table below will show the relative strength of our sizes A and B as compared with the Bismuth Antimony Pile of twenty pair, which is usually taken as the standard in Thermo-electric Measurement.

The advantages of the Improved Mineralite Pile are **much greater sensibility, greater mechanical strength,** and **greater durability.**

In preparing the data given in Table I below, we have used a unit area of metallic surface kept at 100° Centigrade and distant from the Pile 10 centimeters. Deflections in each case are read by a galvanometer of standard D'Arsonval type. In Table II, the source of heat is the direct rays of the sun, the experiment being taken on a typical Boston Winter's day.

TABLE I

Unit Area Metallic Surface at 100° Centigrade. 10 Centimeters distant from face of Pile

INSTRUMENT	TIME		
	30 Seconds	1 Minute	2 Minutes
20 pair Bismuth Antimony	9 Divisions	11 Divisions	10 Divisions
Mineralite A	30 Divisions	34 Divisions	36 Divisions
Mineralite B	45 Divisions	52 Divisions	55 Divisions

TABLE II

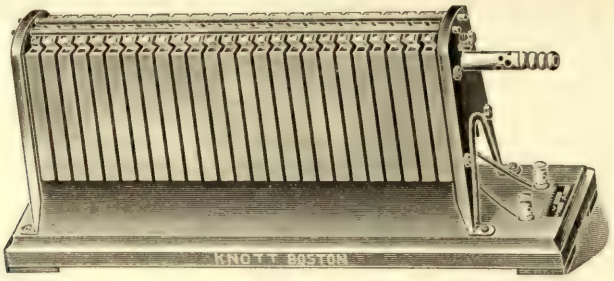
Direct Sunlight as Source of Heat

INSTRUMENT	TIME
	1 Minute
20 pair Bismuth Antimony	17 Divisions
Mineralite A	83 Divisions
Mineralite B	167 Divisions

64–100 IMPROVED MINERALITE THERMOPILE A $14.50
64–110 IMPROVED MINERALITE THERMOPILE B 22.00

OTHER RADIOMETERS. Section 61.

THERMO-ELECTRIC BATTERIES



No. 64–127

Thermo-Electricity has been a matter of study for a number of years, but the principal use of a thermo-electric couple or a thermopile has been that of a sensitive radiometer. The new thermo-electric instrument above illustrated is designed for practical use, — that of a thermo-electric battery. These forms are of simplified construction, low-priced and with highly efficient output. With the larger sizes, small machinery may be operated, incandescent lamps lighted, storage batteries charged, etc. For experiments in electrolysis, they are, perhaps, unexcelled. From the fact that they may be operated instantly and need no attention, their popularity in this country and abroad has been continually increasing. Each battery is supplied complete with burner.

64–125 **THERMO-ELECTRIC BATTERY,** 26 elements, E. M. F. 1.8 to 2.2 volts; current strength on short circuit 3 to 4 amperes.
Complete with Gas Burner . . . . . Duty Free **$6.50**
64–125a ——, same as above, but with Alcohol Burner . . . . . Duty Free **8.35**

64–126 **THERMO-ELECTRIC BATTERY,** similar to above, but larger, 38 elements, E. M. F. 2.8 to 3.2 volts; current strength on short circuit 3 to 4 amperes.
Complete with Gas Burner . . . . . Duty Free **9.80**
64–126a ——, same as above, but with Alcohol Burner . . . . . Duty Free **11.70**

64–127 **THERMO-ELECTRIC BATTERY,** similar to above, but larger, 50 elements, E. M. F. about 4.2 volts; current strength about 4 amperes.
Complete with Gas Burner . . . . . Duty Free **17.40**
64–127a ——, same as above, but with Alcohol Burner . . . . . Duty Free **19.75**

64–128 **THERMO-ELECTRIC BATTERY,** extra large, 100 elements, E. M. F. 4 to 4.5 volts; current strength on short circuit 4 to 5 amperes.
This battery is especially adapted for charging a 7 to 10 ampere storage cell.
Complete with Gas Burner . . . . . Duty Free **25.00**
64–128a ——, same as above, but with Alcohol Burner . . . . . Duty Free **28.25**

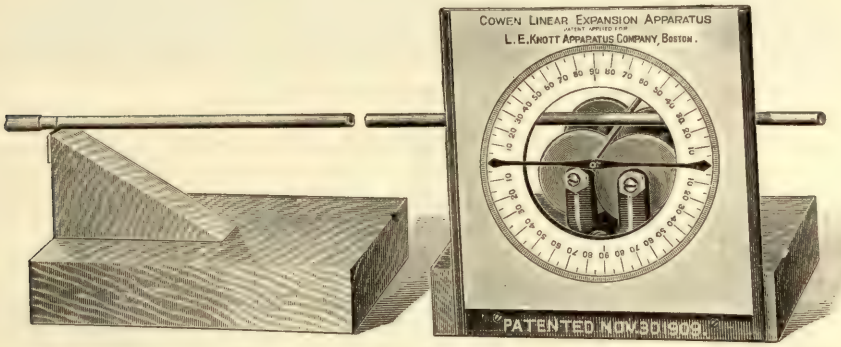
No. 64–160

64–160 **PORTABLE INDICATING ELECTRIC PYROMETER,** for indicating temperatures not exceeding 2000 degrees Fahrenheit or 1100 degrees Centigrade.
This instrument is provided with pivot, jewel-bearing, dead-beat, milli-voltmeter movement, manufactured by the Weston Electrical Instrument Company. It is rugged in structure, durably and handsomely finished. Each instrument is furnished complete in aluminum case and handsome oak protecting box with leather handle and provided with 35 feet of Flexible Duplex Connecting Leads, Patented Cold-End Extension Piece 24 inches long, and Patented Fire End, 36 inches long **$60.00**

64–162 **EXTRA FIRE END FOR RENEWALS,** 36 inches long (standard length) or less . . . . . Each **4.00**

EXPANSION OF MATTER

LINEAR EXPANSION APPARATUS



No. 65–10

65–10 **COWEN'S LINEAR EXPANSION APPARATUS,** for the rapid measurement of linear expansion of solids.

The apparatus consists of a multiplying device on which the solid in the form of a tube rests. Any movement of the tube lengthwise is greatly multiplied and accurately indicated on a graduated dial. All parts are accurately fitted and handsomely finished. The apparatus occupies a small space, yet from its mechanism presents a highly scientific appearance.

Results of extensive use have brought out the following features, — **SIMPLICITY**; no complicated mechanism for clamping the rod and measuring same, the movement lengthwise merely being multiplied by our patented device, the mechanism of which can readily be understood by even the most unscientific mind: **ADAPTABILITY**; this instrument, taking a tube of any length from 20 centimeters up and any diameter desired: **ACCURACY**; in the shortest time possible and with a minimum of trouble, an accuracy in excess of the ordinary form of linear expansion, is possible with this, our patented design, inasmuch as reasonable errors of observation cause only slight errors in final determinations.

Apparatus complete, including one brass tube $3.00

65–11 **STEEL TUBE,** for use with above 45

65–12 **ALUMINUM TUBE,** for use with above 45

65–13 **BRASS TUBE,** as used in above 40

65–14 **GLASS TUBE,** for use with above 20

No. 65–17

65–17 **COWEN COMPENSATION APPARATUS,** as designed by George A. Cowen of the West Roxbury High School, to use in connection with apparatus No. **65–10** in demonstrating the effect of multiple bars of different coefficients of linear expansion as used in the Compound Pendulum.

The apparatus is simple in form, as shown in the cut, the various expanding bars being held together with two brass clamps on the same principle as the multiple bars are held in the Compensated Pendulum.

A most interesting phenomenon is observed when the steam enters from the steam boiler. The tube which is reached first by the steam, expands, causing the pointer to make rapid movement toward the left. When the steam reaches the second bar of the system, this being the bar of greatest coefficient of expansion, the pointer moves to the right to and well beyond the starting point. When the steam reaches the third bar of the system, it will again move to the left, reaching the zero point from which it started and there stop, showing successively the relative expansion of the tubes in the order in which the steam strikes them.

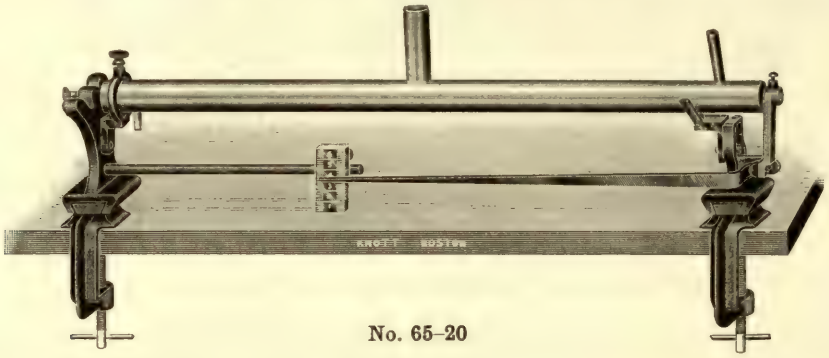
We recommend that this piece of apparatus be placed in the hands of the individual student where possible, although the effect is sufficiently striking to serve well as a lecture table demonstration.

Complete as illustrated $5.00

65–18 **COWEN COMPENSATING ATTACHMENT,** for use with Cowen's Linear Expansion Apparatus No. **65–10** 2.40

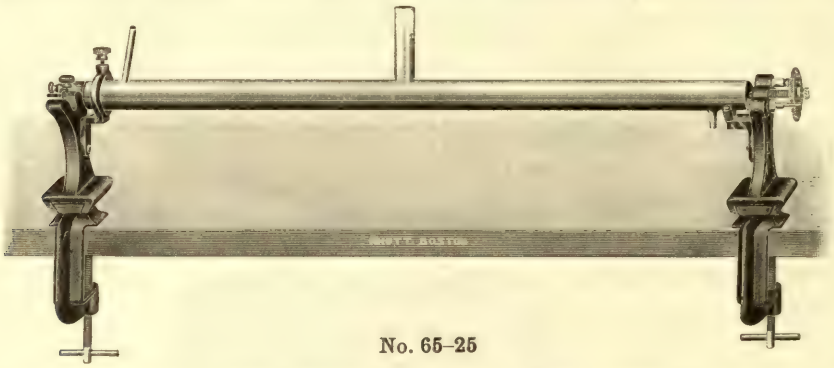
T-BEAM SERIES LINEAR EXPANSION APPARATUS (LEVER AND MICROMETER FORM)

The advantages of this type of apparatus will be readily seen from the cut, — substantial construction, the ends clamped securely to the table avoiding all errors due to the supports not being rigid, the distance between the supports easily varied to meet varying conditions. The metal brace between the two uprights formerly used has been eliminated, doing away with the unavoidable error arising from the expansion of this brace by the heat radiated from the steam jacket. Please note that the supporting ends of our instruments are attached by the well-known Interlocking T-beam Attachment to the standard Basic Clamp " A," a strong and rigid clamp which holds the apparatus securely to the table top. The uniformly accurate results which these instruments give are due to the fact that all possible sources of error have been carefully worked out and eliminated.



No. 65–20

65–20 T-BEAM SERIES LEVER EXPANSION APPARATUS, complete as illustrated without Basic Clamps **$3.25**



No. 65–25

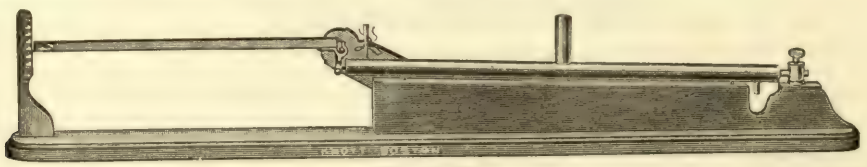
65–25 T-BEAM SERIES MICROMETER SCREW EXPANSION APPARATUS, complete as illustrated without Basic Clamps **$3.85**

The Basic Clamp illustrated above is
No. 5–1000 HARCOURT UNIVERSAL T-BEAM BASIC CLAMP " A," $1.15

THE IMPROVED SPINE-SUPPORTED LINEAR EXPANSION APPARATUS

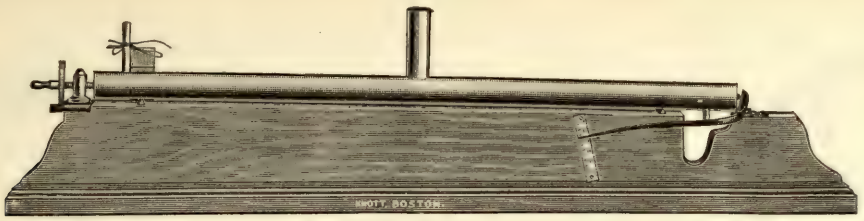
In this series of Linear Expansion Apparatus we wish to call particular attention to the improved method of supporting the tube, it being held lengthwise on the top edge of a substantial oak spine, but not in actual contact with the wood. The design is such that the drip from the falling water or the radiated heat from the tube introduces no error, a very important feature in all designs of apparatus for determining the Coefficient of Linear Expansion.

The apparatus is offered both in the Lever and Micrometer form.



No. 65–30
Patented Sept. 7, 1906

65–30 SPINE-SUPPORTED LEVER FORM EXPANSION APPARATUS, complete, including Brass Rods **$3.75**



No. 65–40

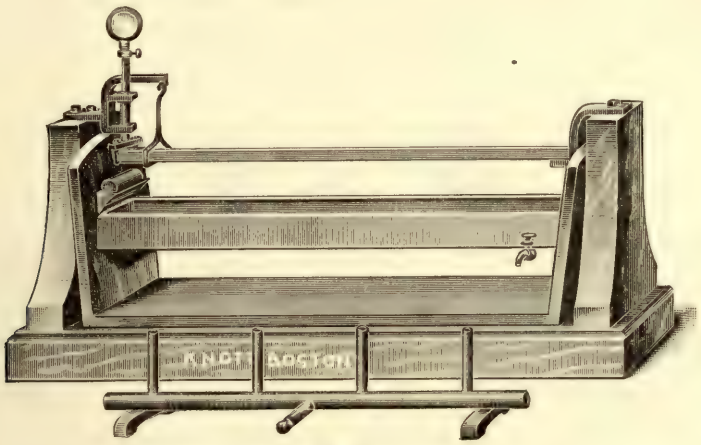
65–40 **SPINE SUPPORTED MICROMETER SCREW FORM LINEAR EXPANSION APPARATUS,** for determining the coefficient of linear expansion of a rod.

This form of expansion coefficient apparatus substitutes a micrometer screw in place of lever for reading the expansion. A lever at the other end of the rod facilitates in the zero readings, indicating positive contacts of the end of the micrometer screw on the rod, thus avoiding the inconveniences of electrical connections and overcoming absolutely the errors to which the electrical method is liable.

Mounted on handsomely finished hardwood support **$4.25**

65–45 **ALUMINUM ROD,** for use with Nos. **65–20** to **65–40** . . . . . **.45**

65–46 **IRON ROD,** for use with Nos. **65–20** to **65–40** . . . . . **.40**



No. 65–60

65–60 **LINEAR EXPANSION APPARATUS,** after Lavoisier and LaPlace, for the accurate determination of the linear expansion of a solid.

This ingenious method consists essentially of a metal trough into which the rod is placed. The expansion of this rod is determined by the reading of a scale in a mirror whose movement is actuated by the movable end of the rod. This scale is read by means of a telescope. It may, therefore, be seen that the least movement of the rod is greatly magnified, the determination of the expansion of the rod being merely a matter of algebraic computation when it is considered as one of the factors in the ratio of homologous sides of homologous triangles with the readings of the mirror. The apparatus is constructed by a well-known European manufacturer whose quality is a standard of excellence. It is substantially built and its structure is such as to allow of extreme accuracy; the only accessories needed are those of the Reading Telescope and Scale.

Complete as illustrated, with four-tube burner for heating the oil or water that may be used in the trough to cause expansion of the rod . . . . . Duty Free **$47.75**

COEFFICIENTS OF EXPANSION FOR 1° C.

The length L of a body is increased by BL for each degree of increased temperature, and its volume V by 3BV.

Aluminum	0.000023	Lead	0.000029
Ash with the grain	0.0000095	Pine with the grain	0.0000054
Brass	0.000019	Platinum	0.000009
Copper	0.000017	Platinum-iridium	0.000009
German Silver	0.000018	Silver	0.000019
Glass	0.0000085	Steel (Annealed)	0.000011
Gold	0.000015	Tin	0.000023
Iron	0.000012	Vulcanite	0.00008
Zinc	0.000029		

The volume V of mercury increases 0.000181 of its volume at 0° for 1°.

No. 65–80

No. 65–75

65–75 COMPOUND BAR, for showing unequal expansion of metal.

This apparatus consists of two welded pieces of metal, iron and brass, which when heated will show their unequal expansion qualities by bending in the form of an arc, the inner part of which will be the metal of lesser expansibility.

Complete as illustrated, with handle for comfortable heating **$0.95**

65–80 COMPOUND BAR WITH INDICATOR, for showing the unequal expansion of two metals.

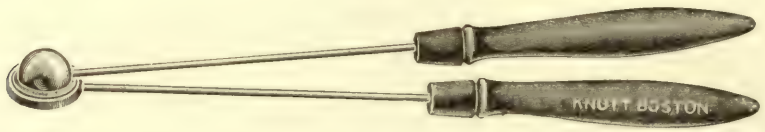
This is an ingenious device for registering on a dial the expansion of the metal of the greater expansibility **4.00**

No. 55–80

55–80 TREVELYAN'S ROCKER, for illustrating that musical vibrations are maintained by communication of heat.

The apparatus consists of a brass rod with a V groove milled lengthwise. To this rod is fastened a metal handle with ball end. When this bar is heated at some point below the melting point of lead and placed so that the edges of the V groove rest on the lead casting as indicated, the bar begins to emit a harsh note. This note may be made to rise in pitch by slightly pressing on the bar.

Trevelyan's Rocker with Lead Rest **$2.00**



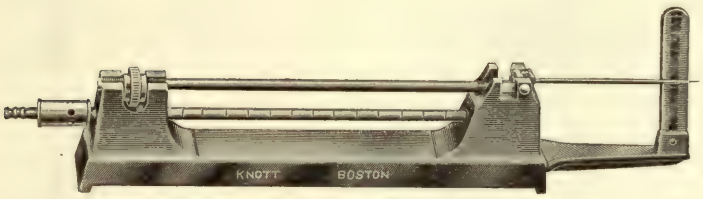
No. 65–110

65–110 GRAVESEND BALL AND RING, for illustrating expansion of metal upon application of heat and contraction upon withdrawal.

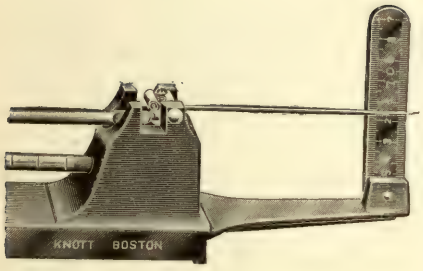
The apparatus consists of a polished metal ball and a ring through which the ball at ordinary temperature will just pass, each of which is attached to a metal rod with handle end.

At ordinary temperature, the ball will just pass through the ring, but when heated, it cannot be forced through. Cooled below ordinary temperature, it will fit loosely **$1.25**

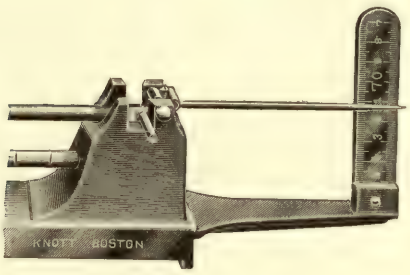
17–60 COMPENSATED PENDULUM, illustrating method of time compensation by application of unequal expansion of rods **12.35**



No. 65–130



No. 65–130 (Fig. 2)



No. 63–130 (Fig. 3)

65–130 PACKARD'S BREAKING BY EXPANSION AND CONTRACTION APPARATUS. This piece of apparatus has been designed to demonstrate most effectively the power exerted by an expanding or contracting metal bar. The expansion is obtained by a burner in tube form indicated in the illustration. The power exerted by the expanding or contracting rod is presented most strikingly by the breaking of a steel bar placed in the slot in the end and at right angles resting against knife edge supports.

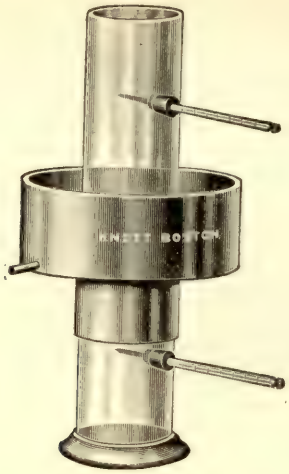
It will thus be seen that whether the rod be heated by the tube, or allowed to contract in the process of cooling, the bar will be broken and at the instant of breaking the lever will be thrown violently, the results being therefore striking by the breaking of the bar, the sudden rising of the pointer and the noise, leaving no doubt in the student's mind that great force has been exerted.

In addition to the above features the instrument makes a most satisfactory lecture table piece for teaching briefly but quickly the principle of expanding by heat.

The substantial construction, careful workmanship and correct design make this a most satisfactory lecture table demonstration piece. Twelve steel bars for breaking supplied with each instrument.

Please note that the above instrument serves to teach the force exerted by an expanding rod, force exerted by a contracting rod and the relative amount of expanding and contracting by heat.

Complete as illustrated $9.50



No. 65–150

No. 65–160

65–150 HOPE'S MAXIMUM DENSITY OF WATER APPARATUS, for illustrating the point of Maximum Density of Water; also for explaining reason why the surface of a pond may be covered with ice while underneath is water.

The apparatus consists of a cylindrical jar in the sides of which, near top and bottom, are drilled holes to contain sensitive thermometers. Around this jar about midway between these holes is sealed a copper ice container.

In use, the jar is filled with water sufficient to immerse the upper thermometer bulb. A freezing mixture is placed in the copper ice container. As the water in the jar cools, the density is increased, the more dense portions sinking to the bottom, where its temperature will be registered by the lower thermometer. It will be noted that the reading of this thermometer will be lower than that of the upper until 4° Centigrade is reached, at which point the reading will remain stationary, whereas the upper will continue to descend until 0° Centigrade is reached.

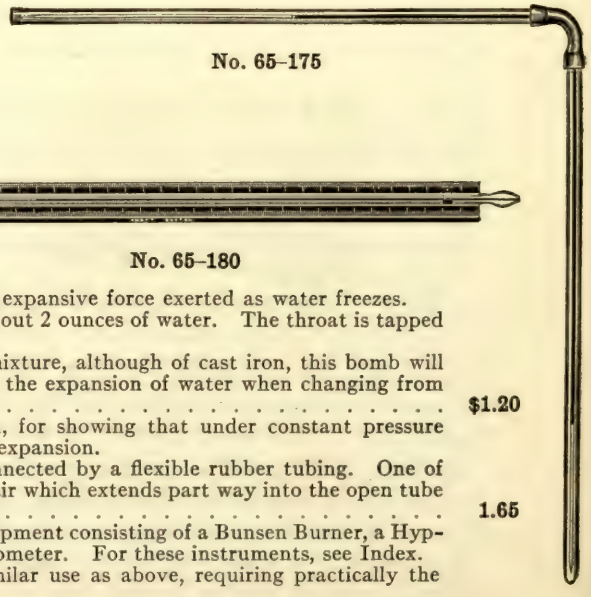
Complete as illustrated, with rubber stoppers for thermometers but without thermometers **$5.00**

THERMOMETERS. Section **63.**

65–160 DESPRETZ WATER THERMOMETER, for indicating cubical expansion of liquid or for determining the maximum density of water.

This device consists of a tube of known volume with neck graduated to cubic centimeters. In determining the maximum density of water the results are positive, inasmuch as the water contained in the thermometer will sink to its lowest point when the water bath into which the bulb is placed has a temperature of about 4° Centigrade **2.00**

No. 65–170



No. 65–175

No. 65–180

65–170 FREEZING BOMB, illustrating the tremendous expansive force exerted as water freezes.

Consists of a cast-iron sphere cored to contain about 2 ounces of water. The throat is tapped to receive a screw plug.

When filled with water and placed in freezing mixture, although of cast iron, this bomb will burst from the tremendous force exerted from the expansion of water when changing from the liquid to the solid state **$1.20**

65–175 CHARLES LAW TUBE, after Hall and Bergen, for showing that under constant pressure different gases possess the same coefficient of expansion.

This consists of two tubes of capillary bore, connected by a flexible rubber tubing. One of these tubes has a closed end and contains dry air which extends part way into the open tube in which is an indicating globule of mercury **1.65**

NOTE. The use of this tube presupposes an equipment consisting of a Bunsen Burner, a Hypsometer, an Ice Tray, a Meter Rod, and a Barometer. For these instruments, see Index.

65–180 WATERMAN'S CHARLES LAW TUBE, for similar use as above, requiring practically the same accessories.

The apparatus consists of tube of capillary bore, one end of which is sealed and contains dry air stoppered by a globule of mercury. This tube is mounted on a graduated backing for direct measurement of air expansion **1.75**

MEASUREMENT OF THE QUANTITY OF HEAT

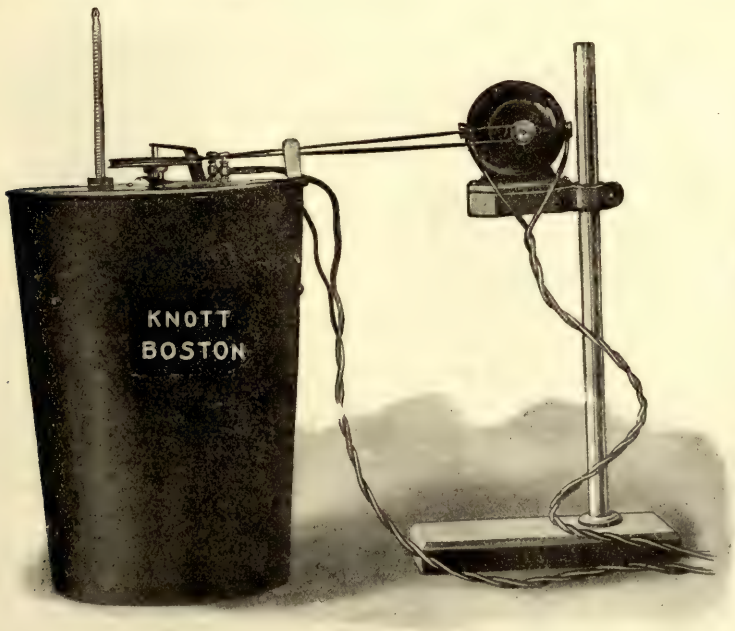
CALORIMETERS

66–10 PARR'S STANDARD CALORIMETER, for determining the calories of heat developed by the combustion of bituminous and anthracite coals, lignites, coke, etc.

No. 66–10

The apparatus consists of a cartridge in which is placed the combustible material in the form of a powder and mixed with a chemical compound. This cartridge is placed in a measured quantity of water in an insulated calorimeter can. This calorimeter can is contained within two insulating vessels with air spaces between. The pulley noted in the illustration operates the cartridge and is provided with small vanes for causing a constant uniform stirring of the water. This pulley may be driven by any convenient means at hand. The illustrations show it in use driven by Electrical Motor. In use, the coal or combustible substance is ground to pass through a 100 mesh sieve and a weighed quantity is put into the cartridge together with a chemical compound. A measured quantity of water is then placed in the insulated calorimeter can. The stirrer is then set in motion, operated either by water or electric power. After a constant temperature has been obtained, ignition is effected by means of a short piece of hot wire dropped through the stem of the cartridge. Extraction of the heat is completed in from four to five minutes. The maximum reading is taken and the rise of temperature multiplied by a simple factor gives the heat in B. T. U. per pound of coal.

The complete calorimeter outfit includes a fine thermometer graduated to $\frac{1}{20}$ degree Fahrenheit with certificate of accuracy, a two-liter measuring flask, chemical receptacle, measuring cup, 5-inch 100 mesh brass sieve with bottom, chemicals sufficient for 10 determinations, pincers, ignition wire, reading lens, and camel's hair brush **$70.00**



No. 66–11

66–11 PARR'S STANDARD CALORIMETER, same as above, but equipped for electric ignition **$75.00**
66–12 WATER MOTOR AND SUPPORT . . . . . Extra **5.00**
66–13 ELECTRIC MOTOR, Lamp series, as illustrated above . . . . . Extra **12.00**
66–14 SUPPORT FOR ELECTRIC MOTOR, as illustrated above . . . . . Extra **2.50**

No. 66–35

66–35 DOUBLE WALL CALORIMETER, form similar to one in use at University of Cincinnati for specific heat and radiation experiments.

The apparatus consists of a polished and nickeled brass vessel provided with wooden ring for supporting a second and smaller polished and nickeled brass vessel as well as one black oxidized. A cover with hole for thermometer is supplied with the outfit.

Complete as illustrated, including outside vessel and two smaller inner vessels, one polished and nickeled, the other blackened, wooden supporting ring and cover **$1.90**

66–36 CALORIMETER, outer vessel of above, polished and nickeled . . . . . **.60**

61–136 CALORIMETER, inner vessel of above, polished and nickeled . . . . . **.50**

61–137 CALORIMETER, inner vessel of above, oxidized black . . . . . **.55**

61–138 WOODEN SUPPORTING RING, for above . . . . . **.15**

61–139 WOODEN COVER with hole for thermometer . . . . . **.15**

No. 66–45

No. 61–205

No. 66–65

No. 66–75

66–45 DOUBLE WALL CALORIMETER. This is a heavy spun copper can with ledge for holding a fiber ring on which rests a second but smaller spun copper vessel. A cover of wood with hole for stirrer and one for thermometer is provided. Vessels are polished and nickeled inside and out.

Complete as illustrated **$3.45**

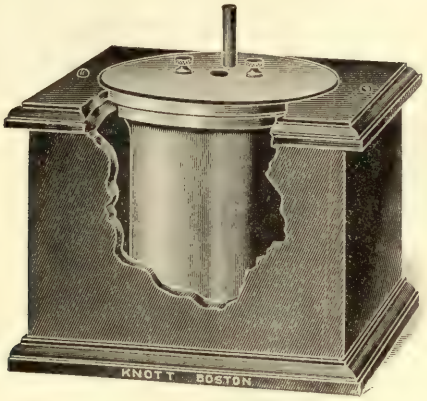
61–205 DOUBLE WALL CALORIMETER, of glass. This is a double-walled vessel with outlet for evacuating chamber between walls. It will be found invaluable in calorimetric work **3.25**

66–65 CALORIMETER, for general laboratory usage in secondary school work in calorimetry.

This is the popular nickel-plated brass calorimeter used so frequently in determinations of specific heat, latent heat of melting ice, latent heat of evaporization, and quite frequently for dew point tests. Capacity about 1 liter . . . . . **.50**

66–75 BUNSEN'S ICE CALORIMETER, standard form, consisting of a bulb with sealed-in test tube and bent mercury tube **1.25**

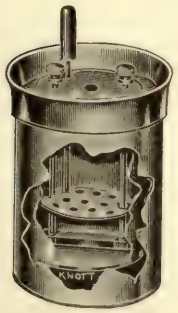
ELECTRIC CALORIMETERS



No. 66–100

66–100 THE IMPROVED ELECTRIC CALORIMETER, designed after Stewart & Gee's "Practical Physics," Lesson 47. This instrument was designed for the purpose of applying Joule's Law in the determination of the constant of a Galvanometer, consequently the best possible results must be obtained. The calorimeter proper is of the form shown under No. **66–105.** This is placed in the secondary chamber as shown in the illustration, the space between the outer chamber and the polished surface of the outer wall of the calorimeter being filled with an insulating compound composed largely of magnesium carbonate.

Complete as illustrated **$13.50**



No. 66–105

No. 66–110

66–105 DOUBLE WALL ELECTRIC CALORIMETER, after Millikan & Mills' "Electricity, Sound and Light," Experiment 4, for testing the calibration of a voltmeter by an absolute determination of potential difference.

This calorimeter consists of two heavy copper vessels, the inner of about 350 cubic centimeters capacity, insulated from and supported on the outer by a fiber ring. A coil of fine platinum wire is wound on an insulating strip which is connected to two brass rods. These rods extend through the cover and end in binding post terminals. Two holes are provided in this cover, one for a thermometer, the second for a handle of a stirrer, which has heat insulating end.

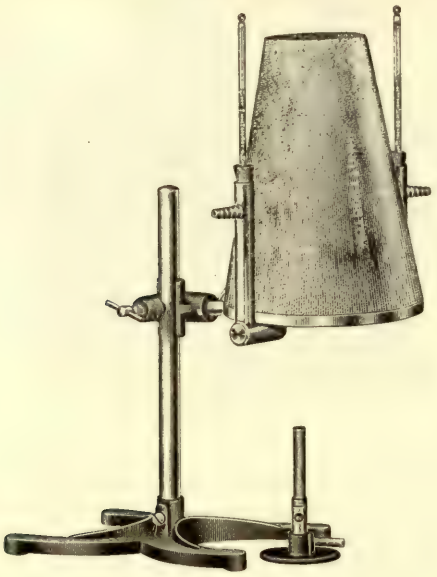
Complete as illustrated **$11.25**

66–110 STUDENTS' ELECTRIC CALORIMETER, for determining the number of calories of heat developed in a wire; also for the study of Joule's Law.

The apparatus consists of a glass jar in the neck of which is placed an insulating cover bearing two rods each terminating in a binding post connected to the ends of a coil of resistance wire. In the center of this cover is a hole for the thermometer.

Complete as illustrated, without thermometer **2.60**

JUNKER'S CALORIMETER



No. 66–125

66–125 SIMPLIFIED JUNKER'S CALORIMETER, for determining the calorific power of combustible gases. In the design above illustrated the heated gases enter the inner chamber of a triple-walled vessel. Within this chamber these gases come in contact with a coil of copper tubing through which a current of water continually flows. The temperature of this water is noted at entering as well as upon issuing from the coil, by the means of the thermometers noted in the illustration. In order to determine the B. T. U. the quantity of gas consumed and the quantity of water passed through the apparatus must be determined in addition to the difference in temperature. In determining the quantity of gas consumed we advise our No. **66–130** Thorpe Gauge.

This instrument is substantial in structure, the fundamental part consisting of a casting to which are mounted the two thermometer tubes. On this casting is mounted a double-walled metal chamber surrounded by an insulating compound. The ends of the copper circulating coil supported from above to the inner metal vessel are connected through the casting to the thermometer tubes. The instrument may be mounted on our special stand as illustrated or may be attached to any tripod stand by means of a clamp.

Simplified Junker's Calorimeter only, without mounting of any kind **$15.00**

The support above illustrated consists of:

5–770	**RIGHT ANGLE CLAMP**	**$0.95**
5–20b	**SUPPORT ROD**	**.52**
43–271	**HARCOURT SPECIAL H BASE**	**1.00**

66–130 THORPE GAUGE, for measuring either pressure of gas or rate of gas flow.

To read pressure of gas screw cap down over outlet at the top and connect gas supply to the inlet. Index on left scale gives reading of pressure in inches of water. With cap removed from outlet and gas allowed to flow through the gauge, the indicator registers on right hand scale the rate of flow of the gas in cubic feet per hour **12.00**

SUBSTANCES FOR SPECIFIC HEAT DETERMINATIONS

No. 66–200

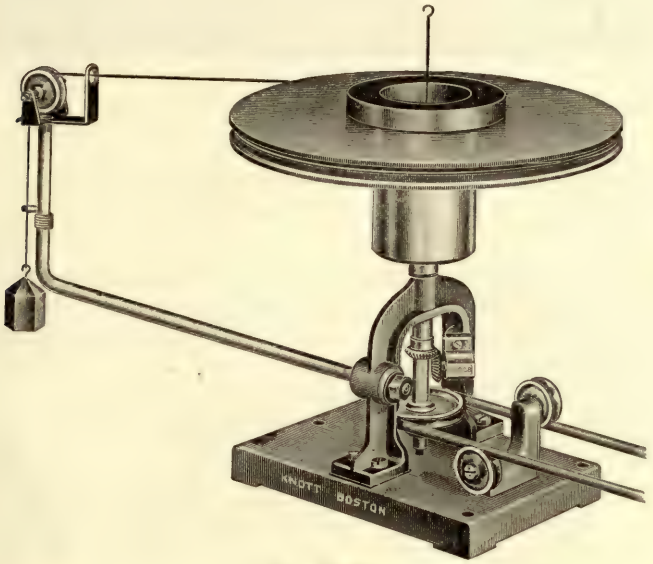
66–175	**LEAD SHOT**	Per Pound	**$0.15**
66–177	**COPPER SHOT**	Per Pound	**.45**
66–179	**ALUMINUM SHOT**	Per Pound	**1.05**
66–181	**GLASS BEADS**	Per Pound	**1.00**

66–200 TYNDALL'S SPECIFIC HEAT APPARATUS, for qualitative determination of the comparative specific heats of different metals.

The apparatus consists of a tripod on which are supported a disc of paraffine, 5 balls of different metals with handle for holding balls while heating them, and a tin plate for casting new paraffine discs. The balls may be heated either in boiling water or by the flame from a Bunsen burner or spirit lamp at the intersection of the rods bearing the balls.

Apparatus complete as above described **$2.00**

MECHANICAL EQUIVALENT OF HEAT



No. 67–20

67–20 MECHANICAL EQUIVALENT OF HEAT APPARATUS. In the above illustrated machine a vertical spindle carries at its upper end a brass cup. Into an ebonite ring concentric with this brass cup there fits tightly one of a pair of hollow, truncated cones. The second cone fits into the first one and is provided with a pair of steel pins which correspond to the two holes in a grooved wooden disc. In the experiment this disc prevents the inner cone from revolving when the spindle and the outer cone revolve. It is the friction between the two cones which converts into heat the mechanical energy supplied. A cast-iron ring resting on the disc and fixed by two pins serves to give a suitable pressure between the cones.

A grooved pulley is fixed to the spindle and by a round belt passing around this and also around a hand wheel motion is imparted to the spindle. A pair of guide pulleys prevent the belt from running off the pulley. A horizontal, continuous revolution counter actuated by a pair of beveled cog wheels registers the number of revolutions made by the vertical spindle. To the base of the apparatus one end of a bent steel rod is attached. This rod can be fixed in any position by a nut beneath the base. The other end of the rod carries a cradle in which runs a small guide pulley, the upper groove of which is on the same level as the disc. This cradle turns freely about a vertical axis.

In use a fine string fastened to the disc and passing along the groove passes over the pulley and to its end is fastened a mass of 200 to 300 grams. The speed of the hand wheel is regulated so that the friction between the cones just causes this mass to be supported at a nearly constant level. The friction machine is firmly clamped to one table and the hand wheel clamped to the other table at a distance of 10 feet or more. A thermometer is hung from a support so that it passes through the central aperture in the disc and almost touches the bottom of the inner cone. This thermometer should also pass through the hole in the stirrer. It is advised also that before putting the cones together the rubbing surfaces be carefully cleaned, and four or five drops of oil must be put between them. Exceedingly accurate results are possible with this instrument and it has become a standard laboratory instrument for the correct determination of mechanical equivalent of heat.

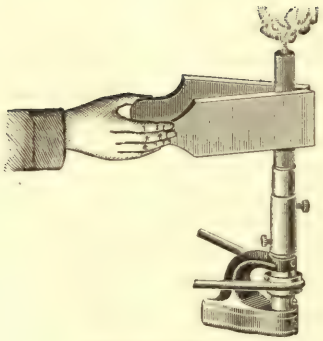
Apparatus complete as illustrated without weight **$30.00**

HAND WHEEL. See **ROTATORS.** Section **21.**

No. 67–25

67–25 MECHANICAL EQUIVALENT OF HEAT TUBE WITH METAL CAP, after Millikan & Gale's "A Laboratory Course in Physics," Experiment 20, for determining the mechanical equivalent of heat of shot.

This apparatus consists of a tube 1 meter in length, built of heavy corrugated board, covered inside and out with tough wrapping paper. The ends of this tube are closed by close-fitting metal screw caps. This tube must not be confused with the many on the market which have ends closed by stoppers. **$0.70**



No. 21–120

No. 67–50

21–120 TYNDALL'S HEAT BY FRICTION APPARATUS, for illustrating with Rotator the heat caused by friction on a brass tube while it is rotating rapidly **$2.00**

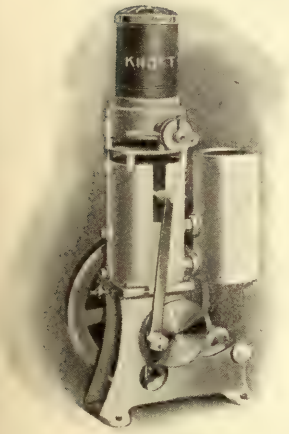
67–50 FIRE SYRINGE, illustrating the production of heat by the rapid compression of gases.

This apparatus consists of a heavy brass cylinder, about 20 centimeters long, provided with tightly fitting piston. On the end of this piston is a holder for a small piece of tinder. This cylinder is mounted on a convenient foot rest.

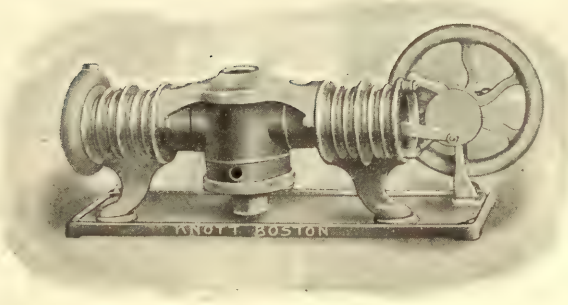
In use, a small tuft of tinder is placed in the holder on the piston and moistened with either ether or carbon disulphide that the experiment may be more effective. If now the piston is driven rapidly to the bottom of the cylinder, the compression of the air generates heat sufficient to set fire to the tuft of tinder.

Complete with piece of tinder **1.75**

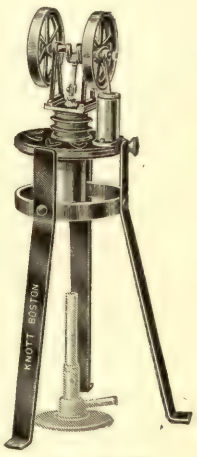
HOT AIR AND GAS ENGINES



No. 68–10



No. 68–15



No. 68–20

68–10 WATER-COOLED UPRIGHT HOT AIR ENGINE, for use in the study of air expansion engines and to secure power up to 1/16 horse power.

This engine, about 26 inches high, weighing about 65 pounds, consumes 8 cubic feet of gas per hour and will give speed of about 300 revolutions per minute. The fly wheel has a diameter of about 10 inches and the engine is provided with pulleys of 2½ and 4 inches diameter for a ¼ inch round belt.

These engines will be found of great utility in the laboratory, running especially smooth, giving the maximum power. The water for cooling is contained in a tank that is a part of the motor and requires no attention except that of keeping filled.

Complete with Gas Burner **$35.00**

68–11 WATER-COOLED UPRIGHT HOT AIR ENGINE, same as above, but designed for use with gasolene burner **37.50**

68–15 HOT AIR MOTOR, for use in schools and colleges in the study of air expansion motors; also readily adapting itself to the operating of small machinery models, etc.

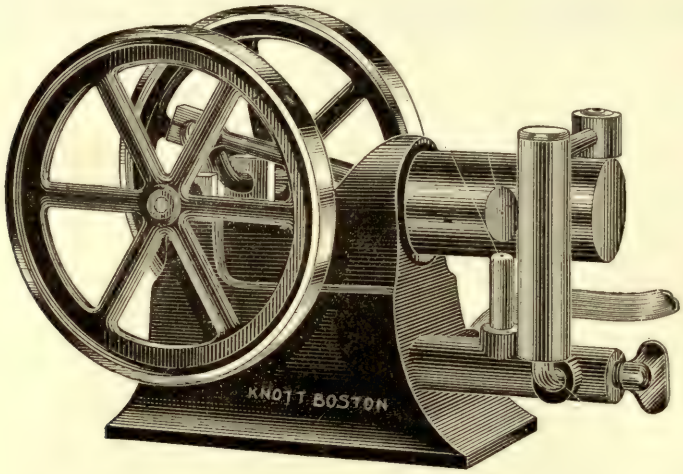
This is an air-cooled motor with adjustable bearings and runs smoothly and silently. It is 18 inches long by 6 inches diameter, weight about 16 pounds. The fly wheel has a diameter of 6 inches and pulley of 1¼ inches.

This engine may be run on either gas or alcohol and either types of burners will be supplied as requested **15.00**

68–20 UPRIGHT HOT AIR ENGINE. A simple working model of an engine operated by air expansion. This small motor is designed to illustrate the principle of the more complex hot air motors and which can be purchased at a minimum price. It will readily run from the heat of a single Bunsen burner or from the heat supplied by a small alcohol lamp.

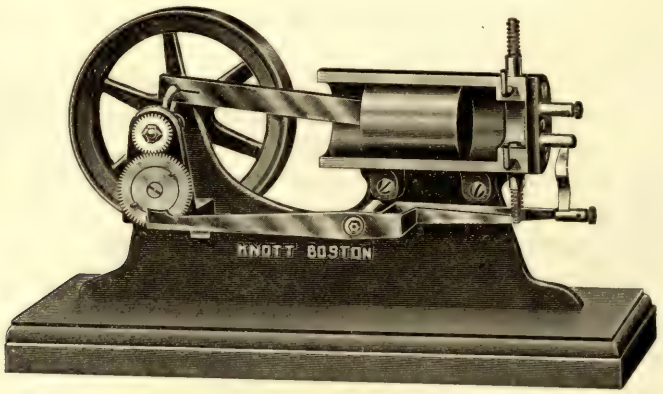
Its effectiveness of operation readily recommends itself for consideration. Complete as illustrated, on tripod **12.00**

68–30 HORIZONTAL HOT AIR ENGINE. This is a design illustrating, in a similar manner as No. **68–20,** the principle of air expansion motors. It is of simple design, but will readily operate from the heat of a small alcohol lamp **$3.75**



No. 68–40

68–40 GAS ENGINE, illustrating motive power, operated by gas explosion.
This is a small-sized model made of iron and brass. It is about 6 inches long, 3 inches wide, and weighs 3 pounds. Speed varies from 200 to 700 R. P. M.; enameled and nickel-plated.
This engine will be found an excellent model for demonstration.
Complete with directions **$2.90**



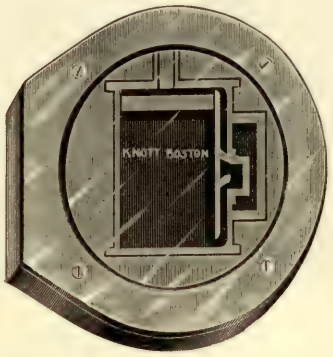
No. 68–50

68–50 FOUR-CYCLE GAS ENGINE MODEL. The model above illustrated represents in section a four-cycle commercial gas engine. As may be noted, all parts are represented in their proper positions and may be shown in actual operation by merely turning a crank, the movement of parts being caused by a succession of gears.
The model is complete with all essential parts, — exhaust and intake valves, piston head, spark plug, etc. all being shown of sufficient size for class room demonstration. By an ingenious method of construction partially noted in illustration we are enabled to show the proper moment of ignition giving rise to compression, if the secondary of a Ruhmkorff's coil be connected in series with the spark plug.
This engine is of rigid construction, scientific in every detail, and handsomely finished throughout, the finish of the different parts being such as to accentuate the parts desired. It is mounted on a neatly finished hardwood base **$7.50**

STEAM ENGINES

STEAM ENGINE MODELS

No. 69–10

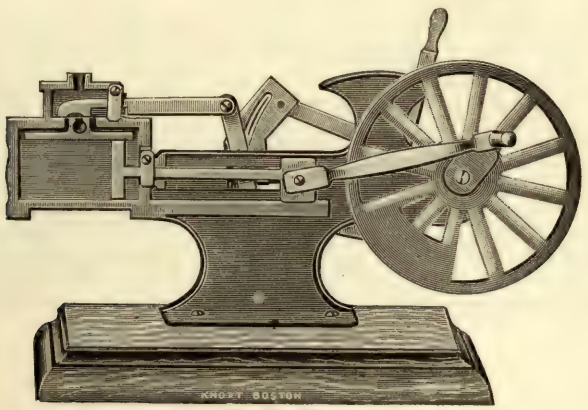


No. 69–20

69–10 WOLLASTON STEAM ENGINE, a simple model to illustrate the expansive force of steam.
This apparatus consists of a vessel as illustrated, in the neck of which is provided a close-fitting piston. In use water is placed in the bulb and heated until steam is formed. Steam will force the piston up the tube. If, now, the steam is condensed by plunging the bulb in cold water, the atmospheric pressure will force the piston back **$2.25**

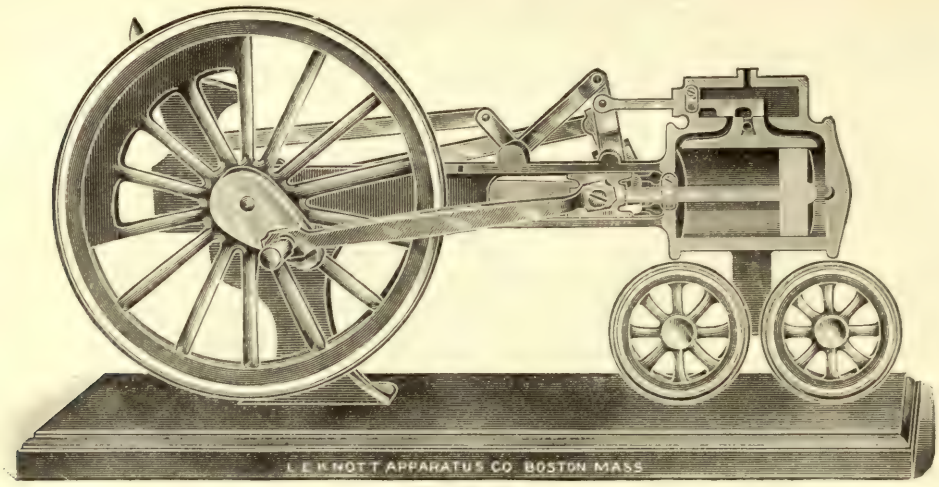
69–20 STEAM CHEST MODEL. This is an interesting model of a simple steam chest demonstrating the opening and closing of the port holes by means of the slide valve.
The apparatus consists of a nickel-plated housing with glass window through which may be seen a working model of a steam chest. By means of a thumb screw at the back, the slide valve may be worked as desired, demonstrating the closing and opening of the port holes.
This is a handsomely finished instrument constructed on pedagogical lines. It will be found very valuable in the lecture hall in that, during the study of the large engines, this little instrument may be passed around the class **3.25**

SECTIONAL MODELS OF STEAM ENGINES



No. 69–30

69–30 SECTIONAL MODEL OF A STEAM ENGINE. This simple model illustrates clearly the movements of slide valve, piston, eccentric, reversal of steam by means of link motion and " cut off." All parts are carefully fitted and adjusted and have been finished to accentuate the different parts. Though the size is sufficient for class demonstration, it is advised that a pupil use this model for the study of the functions and relations of the different parts. As there is no complicated mechanism, the pupil's understanding of the steam engine is complete after a short study of the movements imparted to the different component parts by rotating the fly wheel a few times.
Mounted on a neatly finished wooden base **$3.25**

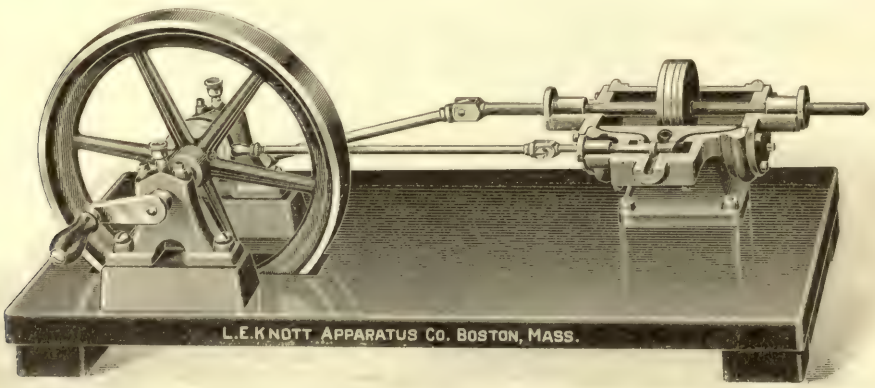


No. 69–35

69–35 **THE IMPROVED EIGHTEEN-INCH SECTIONAL MODEL OF A STEAM ENGINE.** The larger dimensions of this model, together with the more careful workmanship, make it an exceedingly valuable lecture table instrument. Great care has been exercised in making all the parts in a form to resemble as much as possible similar parts in the commercial engine of locomotive type. The sectional view, as is indicated in the cut, shows the steam chest, cylinder, piston, and valves in vertical section through the center. Other features are shown sufficiently "off set" not to interfere with their resemblance to the actual working engine.

The size of this model, it being 18 inches long and 9 inches high, renders it particularly well adapted to lecture table work. In order to assist in the easy differentiation of all the essential parts care has been exercised in the proper coloring so as to make the essential features stand out clear and sharp.

Engine is mounted on a substantial hardwood base, the entire instrument being finished so as to give the most pleasing appearance without interfering with its educational value **$6.75**

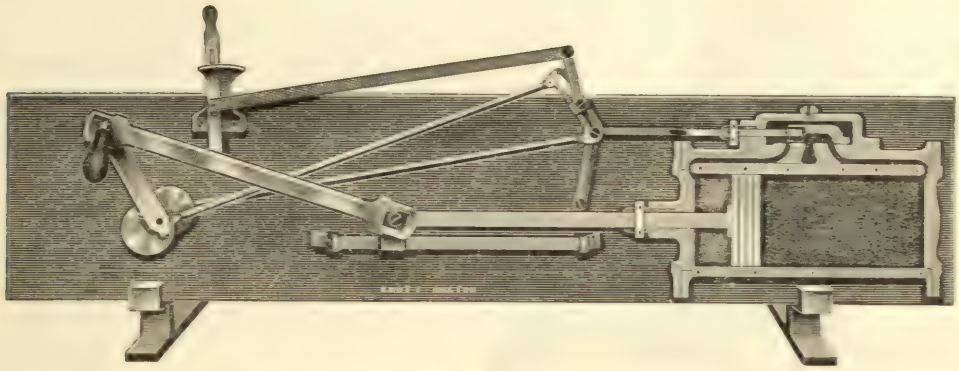


No. 69–40

69–40 **PROJECTION HORIZONTAL MODEL OF A STEAM ENGINE,** a high-grade carefully worked out design of a typical horizontal engine, with eccentric, slide valves, cylinder, and piston clearly indicated as shown in the illustration. The cross section being horizontal, the design is particularly well adapted for showing the engine in operation on the screen by means of the opaque projector.

The essential features are carefully differentiated by color effect so as to give the most striking appearance and easy differentiation on the screen.

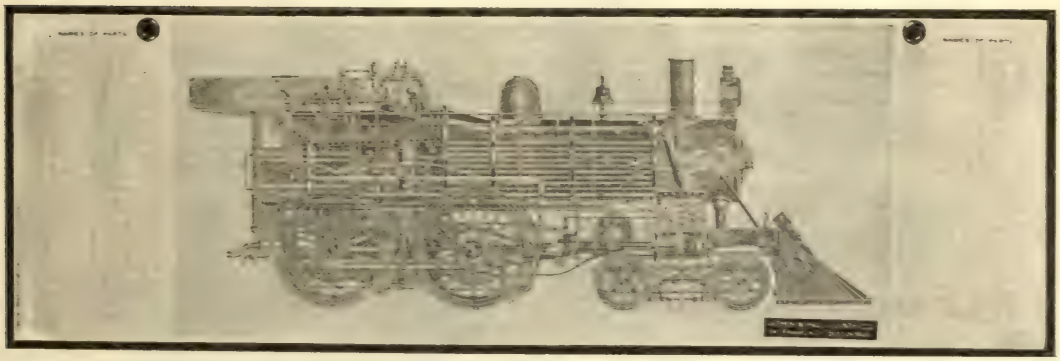
The mounting is most substantial; workmanship is high grade throughout . . . . . Duty Free **$12.00**



No. 69–50

69–50 4-FOOT MODEL OF A STEAM ENGINE, after design suggested by Mr. F. R. Miller, English High School, Boston, Mass. This model, designed especially for lecture table work, as may be judged from its size, has all parts proportional to the total length; thus, piston, slide valve, eccentric, and link motion are all of proportional sizes. The parts are carefully fitted and are mounted on a neat, substantial back supported by cast brackets. As in the smaller models, all parts of a standard steam engine capable of school illustration are brought out in this model. From its large size and the ability of students in the rear of the lecture hall to see all movements clearly it is highly advised as a lecture table instrument.

Complete as illustrated **$24.50**

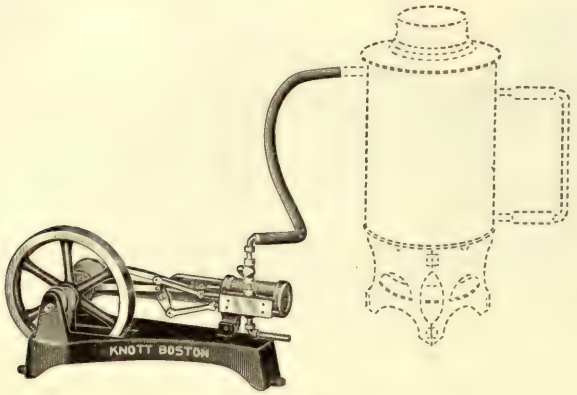


No. 69–55

69–55 LOCOMOTIVE CHART, mounted on heavy cardboard arranged so that it can be hung up on the wall. It shows in detail all the parts of an American locomotive. The sectional view, therefore, shows 240 parts all named and numbered. It gives, in addition, complete information regarding the various details of steam engines in general and locomotives in particular.

This is a fascinating and instructive chart and should be in the possession of every laboratory studying Physics **$2.25**

WORKING STEAM ENGINE MODELS



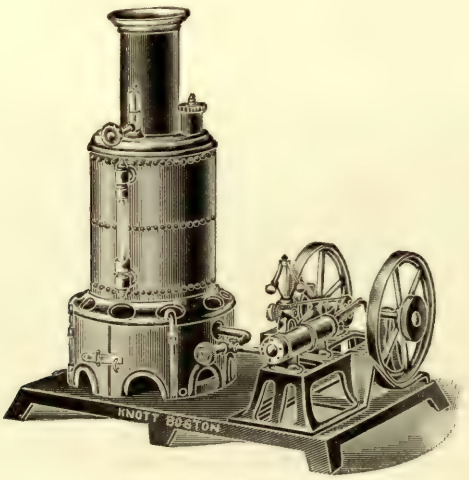
No. 69–75

69–75 WORKING STEAM ENGINE, of small size, for use with Steam Boiler No. **60–365** and consequently designed to work on exceedingly low pressure, operating smoothly without load, when the mercury manometer tube, the most convenient method of determining the exact working pressure, shows only two inches of mercury pressure.

It is a compact, durably built, and substantial little engine. The fact that practically all schools are provided with inexpensive means of obtaining adequate steam pressure such as the Steam Boiler or Hypsometer above referred to, makes this engine of very wide use.

The mechanical or power advantage of working as a high or low pressure engine is readily demonstrated, the low pressure results being obtained either by connecting the exhaust to a condensing chamber, or working it in connection with the air pump.

As will be noted from the illustration, the Engine is mounted on a substantial iron base, presenting very much the appearance of the commercial power engines **$6.25**



No. 69–85

69–85 WORKING MODEL STEAM ENGINE. The model consists of a boiler and an engine both mounted on a nickel-plated iron base the edges of which are polished. The boiler is large and of highly polished blued brass, trimmed with the usual fixtures, substantially as shown in the illustration. The engine frame is of iron and to this frame the cylinder is firmly attached. The inlet of the steam to the cylinder is controlled by a throttle valve, nickel-plated with enamel finished handle. The cylinder, steam chest, and slide rest are cast in one piece and cannot get out of order. A slide valve, eccentric, and connecting rod are all cut from heavy brass and are fastened securely together. The whole engine is in every way strong and durable. This engine runs rapidly and easily, each engine being thoroughly tested before packing and fully warranted. Complete with explicit directions for use and care, in a wooden lock corner box **$9.80**

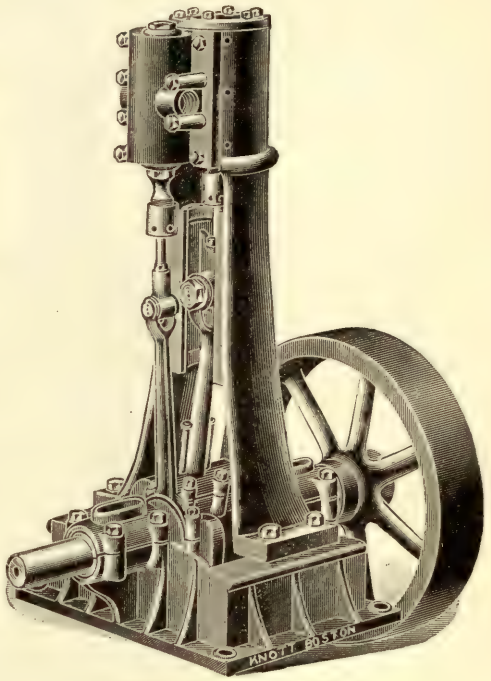
PRACTICAL STEAM ENGINES

The models listed under this heading are without doubt the best small engines on the market. They are capable of heavy duty, being provided with large bearings, adjustable, and excellent provision for oiling. Each engine is carefully designed, being compact and light, yet strong and substantial. Each engine is guaranteed to run at maximum efficiency.

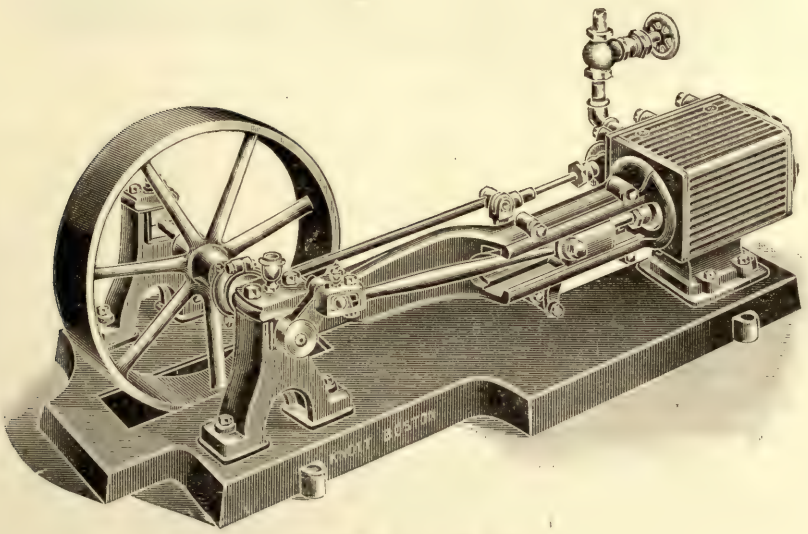
69–105 ONE-QUARTER HORSE POWER VERTICAL ENGINE, cylinder 1½-inch bore, piston 1⅝-inch stroke.
This engine is capable of fully one-quarter H. P., sufficient to run a small dynamo . . . **$40.00**

69–107 ONE HORSE POWER VERTICAL ENGINE.
The cylinder is 2 inches in diameter, giving a 2¾-inch stroke; base 8 × 10 inches, height from base to top of cylinder 20 inches; fly wheel 10 × 2½ inches, weight about 60 pounds. Complete engine **66.00**

69–109 TWO HORSE POWER VERTICAL ENGINE.
This engine consists of two of No. **69–107** mounted on a single base. This combination gives a powerful and substantial engine having no dead centers, which in consequence is very smooth running, is adapted to electric light as well as to other power purposes. It will run at 200 R. P. M. without vibration. Complete engine **125.00**



Nos. 69–105 to 69–107

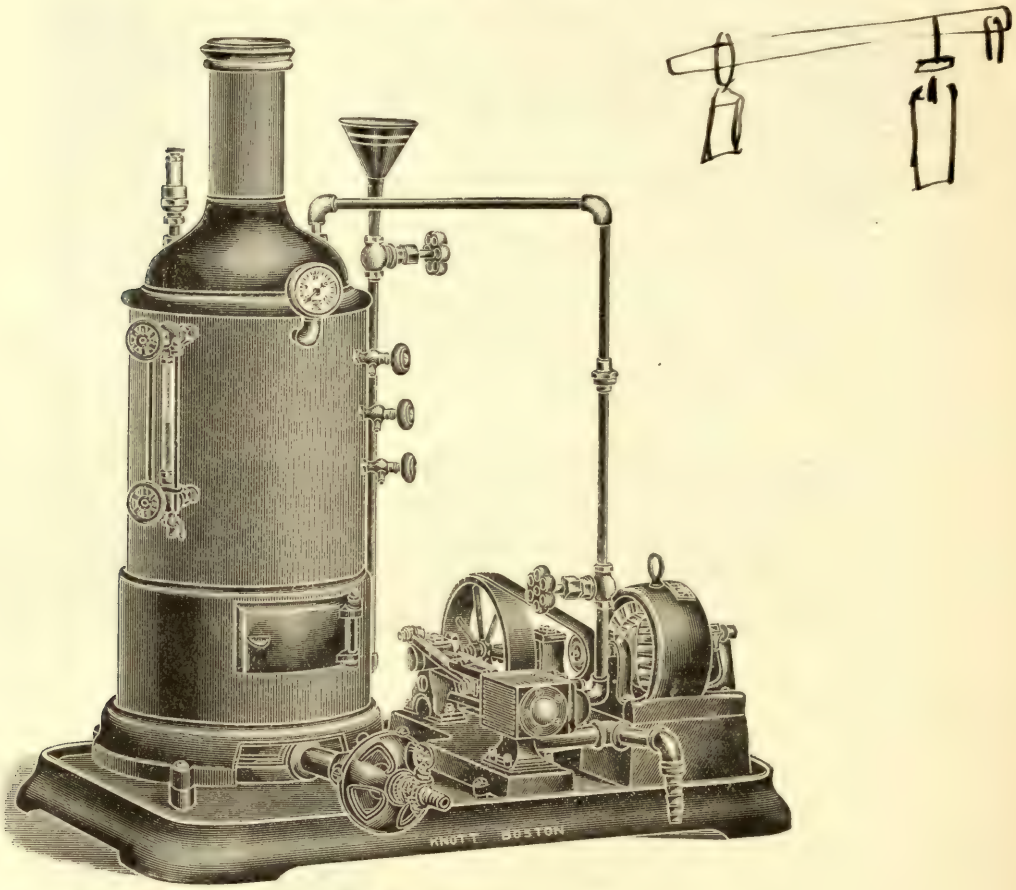


Nos. 69–115 to 69–117

69–115 ONE-QUARTER HORSE POWER HORIZONTAL CORLISS ENGINE, cylinder 1⅛ × 2 inches; bed 12 inches long by 7 inches wide; fly wheel 6 inches in diameter **$24.50**

69–117 ONE-HALF HORSE POWER HORIZONTAL CORLISS ENGINE, cylinder 1¾ × 3 inches; bed 23½ inches long by 30½ inches wide; fly wheel 10 inches in diameter by 2-inch face; approximate weight 40 pounds **55.00**

STEAM POWER PLANTS



No. 69–122

69–120 STEAM BOILER AND ENGINE. The pedagogic merit of a working demonstration Steam Boiler and Engine of commercial type and of sufficient power to be of practical value will be readily appreciated. Models are excellent and perhaps necessary, but the wide-awake student is not satisfied. He desires an actual operating machine of commercial type.

Our outfit, weighing 175 pounds, consists of a commercial ¼ H. P. Engine mounted on same base with, and connected to, a commercial ¼ H. P. Boiler.

The Engine is of the standard Corliss Type, cylinder 1⅛ inches × 2 inches; bed 12 inches long by 7 inches wide; fly wheel 6 inches in diameter. It is carefully designed, and no efforts are spared in its construction to make a practical engine of pleasing appearance. It is provided with attachments to take up wear and maintain adjustments.

The Boiler is of the Vertical Tubular Type, 10 inches in diameter, height over all 21 inches, with a water jacket fire-box and twenty ¾-inch seamless drawn brass tubes, each 10½ inches long. Shell is of $\frac{3}{16}$-inch wrought iron, lap welded, the upper and lower parts of best grade iron; the casing and the stack are of Russia iron, a thoroughly practical machine tested to 200 pounds per square inch. Steam pressure up to 80 pounds may be utilized. It is equipped with gas burner of ample size adapted especially to the work.

The Base is of cast iron of ample dimensions for both Boiler and Engine. It is neatly finished. Engine and Boiler are firmly attached and all connections made. The boiler is completely equipped with necessary valves and gauges so that all that is necessary to start operation is to fill the boiler with water to the proper height as seen by the water gauge, connect burner to gas main, and generate the steam.

Illustration is that of No. **69–122** following, but the outfit described under this number is the same as illustration except that dynamo is not furnished **$74.50**

69–122 **STEAM AND ELECTRIC POWER PLANT.** Frequent calls have been made for an outfit which would illustrate the generation of electric power. By referring to the illustration it will be noted that we have attached on the same base with the engine and boiler above listed a generator of sufficient capacity to demonstrate the principles involved. This generator is of commercial type, 36 watts capacity (6 volts, 6 amperes). It is direct belted and even with the small pressure of 30 pounds may be run to its full speed of 2,200 R. P. M.

Power Plant complete, as illustrated **88.75**

VERTICAL TUBULAR BOILERS

The engines previously listed require a steam pressure. To satisfy this requirement we offer herewith the Vertical Tubular Boilers.

These boilers are of 3/16 inch wrought iron, lap welded. The upper and lower parts are of the best gray iron. The casing outside and the stack are of Russia iron. The boilers of the vertical tubular type have 3/4 inch seamless hard drawn brass tubes with a water firebox. Each boiler is tested to 250 pounds cold water pressure and is safe to run at 100 pounds steam pressure.

The equipment consists of a steam gauge and safety valve, a water gauge, and three gauge cocks; steam and water pipes with valves. These boilers can be fired with hard coal, charcoal, gas, or gasolene.

69–125 **ONE-QUARTER HORSE POWER BOILER,** base 10 inches in diameter, height 21 inches, firebox 5 × 7 inches, 20 brass tubes, water line from floor 14 inches, shipping weight 90 pounds.

Complete with grate for coal **$31.00**

69–126 **GAS BURNER,** for above boiler **6.75**

69–130 **ONE-HALF HORSE POWER STEAM BOILER,** diameter 16 inches; height 31 inches; firebox 6 × 9½ inches; 32 brass tubes, water line from floor 22 inches, shipping weight 250 pounds.

Complete with grate for coal **48.00**

69–131 **GAS BURNER,** for above boiler **15.00**

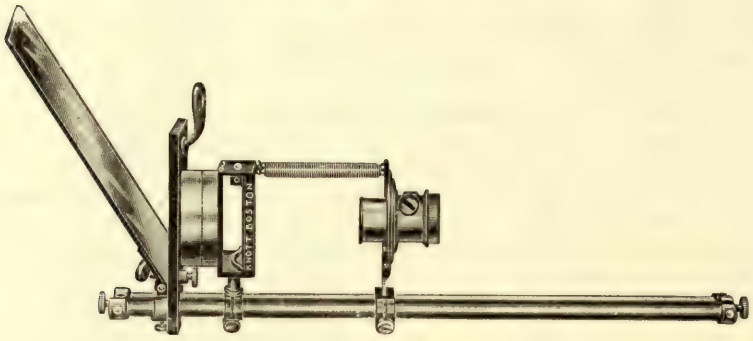
69–135 **ONE AND ONE-HALF HORSE POWER STEAM BOILER,** diameter 21 inches, height 41 inches, firebox 9 × 30½ inches, 51 steel tubes, water line from floor 27 inches, shipping weight 425 pounds.

Complete with grate for coal **115.00**

69–136 **GAS BURNER,** for above boiler **18.00**

LIGHT

SOURCES OF LIGHT



No. 70–10

70–10 HELIOPTICON OR SUNLIGHT PROJECTOR. This instrument consists of a square metal plate in which is fitted a large flat ring to which is fastened a long mirror by special patent hinge. This mirror is arranged for adjustment to any angle with the plate by a large screw which passes through the lower portion of the ring. This ring also carries a condensing lens, in cell, and a metal handle by which the ring and its attachments are turned in a vertical plane. A combination of movements enables the mirror to be adjusted to reflect a beam of sunlight in one direction and keeps it in position with but slight attention. Two parallel tubes pierce the metal plate below the ring and are held firmly by clamping screws. This tube track forms a light but rigid bench for the slide stage and objective carrier. It may also be used for an optical bench.

Heliopticon as above described including ¼-size objective, one 4½-inch condensing lens, and slide carrier **$25.00**

No. 70–20

70–15 PORTE LUMIERE, for securing parallel beams of light. This instrument is a "Sunlight Projector" as above illustrated (No. **70–10**) but without condensing lenses, objective or parallel tube tracks. It is essentially the left portion of the above illustrated Heliopticon **12.00**

70–16 ADJUSTABLE SLIT DIAPHRAGM, for use with Porte Lumiere for securing a rectangular beam of light **1.50**

70–17 CYLINDRICAL DIAPHRAGM, with five graded openings for securing pencils of light **1.50**

70–20 UNIVERSALLY ADJUSTABLE HELIOSTAT WITH CLOCK WORK. The instrument illustrated pictures a heliostat capable of universal adjustments to any position. It is manufactured by one of the leading instrument makers of Europe whose guarantee is sufficient recommendation of its quality. It is handsomely finished throughout and capable of very efficient service. Diameter of mirror 10 centimeters. With each heliostat is furnished a black and a silvered mirror and, in addition, a secondary mirror on stand. Duty Free **74.00**

70–22 HELIOSTAT, same as above, but diameter of mirror 5 centimeters . . . . . Duty Free **54.00**

70–30 CLOCK WORK HELIOSTAT, for obtaining a constant parallel beam of sunlight. Fixed inclination furnished on mounted iron base with two mirrors, one black, and the other silvered . . . . Duty Free **24.00**

PARAFFINE CANDLES, for use in photometric work as source of light.

These candles are of standard quality and are furnished in two sizes:

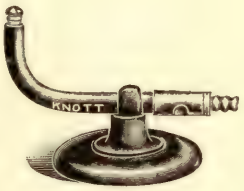
70–50a Sixes (six to the pound) . . . . . Per Dozen **.38**

70–50b Twelves (twelve to the pound) . . . . . Per Dozen **.20**

STANDARD CANDLES. See Section **71.**

No. 70–70

No. 70–90



No. 70–92

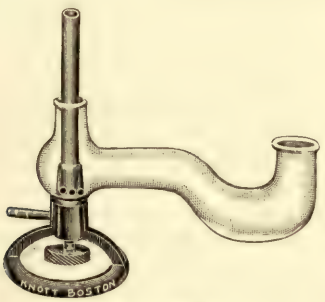
70–70 **KEROSENE LAMP,** for furnishing source of light in photometric experiments.
This consists of a small brass kerosene lamp, with wick and chimney. In order to furnish merely a beam of light and not diffused rays, an asbestos chimney with small opening is supplied in addition to the glass chimney $0.50

70–72 **KEROSENE LAMP** only, with wick and glass chimney 32

70–73 **METAL BOUND ASBESTOS CHIMNEY** only 18

70–90 **ILLUMINATING BURNER FOR GAS,** for laboratory tables. Consists of a burner tube 12 inches high mounted on heavy iron base 80

70–92 **LOW FORM ILLUMINATING BURNER,** curved tube fitted with illuminating tip.
This burner will be found very convenient for use with optical benches 45



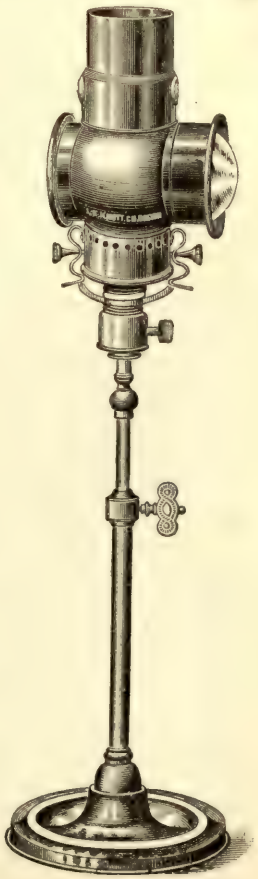
No. 70–95

70–95 **MONOCHROMATIC FLAME BURNER.** Gases of various substances generate in the glass cell and intermingling with the illuminating gas give to the Bunsen flame the distinct monochromatic flame desired.
Complete as illustrated $2.25

70–110 **ELECTRIC LAMP,** table size, adjustable from 12 to 18 inches, made of polished brass, nickel-plated.
Complete as illustrated 8.75

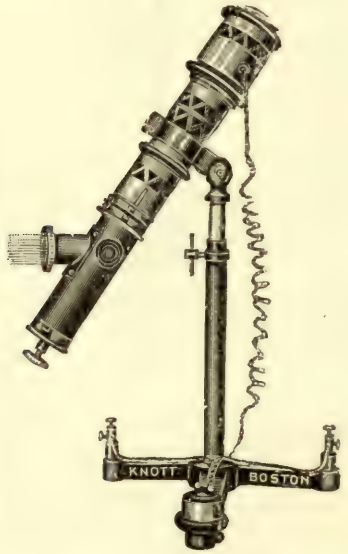
70–112 **GAS LAMP,** similar to above, but arranged for burning illuminating gas.
Complete with Argand Burner and six feet of rubber tubing, with goose-neck connection, stand adjustable from 12 to 18 inches . . . 6.90

70–115 **KEROSENE LAMP,** similar to above, but arranged with reservoir for oil.
Complete 8.75



No. 70–110

LILIPUTIAN PROJECTING LAMP



Nos. 70–125 to 70–126

The Liliputian Projection Lamp was designed for the purpose of giving an intense beam of parallel rays especially suited for work in the physical lecture room. It has also been adapted for transparent projections for use where ready and easily operated lantern outfit is desired. The occasion for offering this apparatus arose from the difficulty of handling larger outfits in a way to most readily give desired results in physical experiments.

A Projection Lantern using from 12 to 15 amperes of current must necessarily require a rheostat of ample proportions, a housing for the lamp designed to properly care for the heat generated, and a condensing system of sufficient size for producing a picture from 12 to 16 feet in diameter at considerable distance from the lamp. It is apparent that an apparatus designed for this work cannot be readily used on the lecture table where an intense, small parallel beam of light only is required. To meet this requirement a small lamp with automatic feed is supported with a simple rheostat on an adjustable upright stand.

The condenser, being small and placed close to the arc, uses a relatively large proportion of the light rays. The rays emerging from the condenser are parallel, forming an intense beam about 3 centimeters in diameter.

The current required is only 1.5 amperes at 110 volts pressure. The form of lamp above illustrated can only be furnished for direct current.

The great variety of uses to which such an apparatus can be put will be apparent at once to those who have long felt the need of such a source of light in lecture table work. As may be noted, the instrument is entirely self-contained. The housing is adjustable in height. The necessary resistance is mounted on one of the legs of the tripod base and binding posts for connections to circuit on the other legs. Close observation of scientific requirements has enabled the manufacturers to furnish a lamp that may be readily moved from place to place, — one that allows of universal adjustment both as to position of lamp and direction of the rays of light proceeding from the apparatus.

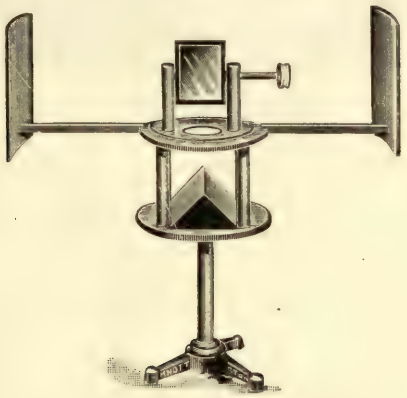
Although exceedingly compact, renewal of carbons is simple. Their position within the housing is readily noted through the window provided.

70–125 LILIPUTIAN PROJECTION LAMP, as illustrated, with resistance on stand for direct current of 1.5 amperes at 110 volts, with ten extra carbons . . . . . Duty Free **$38.50**

70–126 ——, same as above, but with resistance for 220 volts D. C. . . . . Duty Free **44.60**

PHOTOMETRIC AND OPTICAL BENCHES

PHOTOMETERS

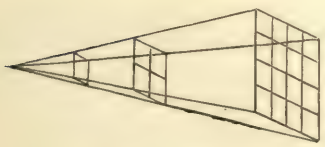


No. 71–10

71–10 RITCHIE PHOTOMETER, for lecture room demonstration.

So little attention has been given to class demonstrations in Photometry that we believe our design will meet with universal approval. A photometer head is provided with a prism, on the faces of which light from two different sources can fall. A movable ring with two uprights which support a tilting mirror on horizontal axis may be turned in all directions that pupils in all parts of the room may test the equality of illumination on both faces of the prism. Light shields are provided to obstruct rays from the two sources of light striking the tilting mirror.

Complete as illustrated, mounted on stand **$9.75**



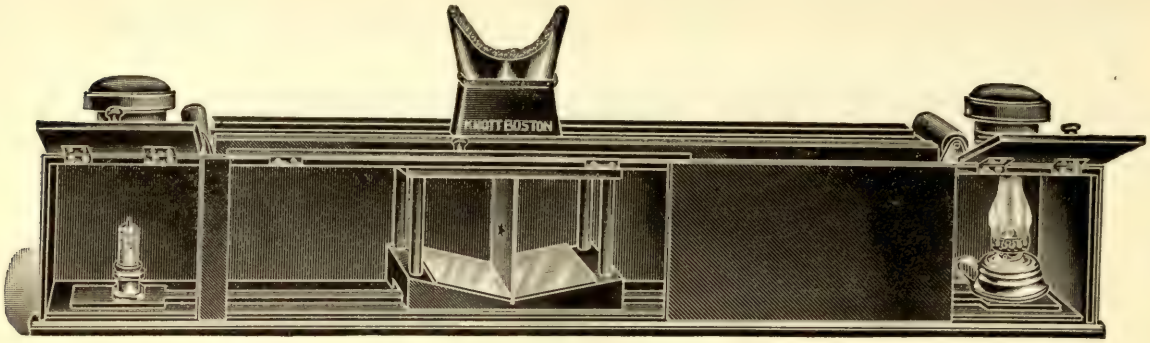
No. 71–20

No. 71–30

71–20 INVERSE SQUARES MODEL, for illustrating that the intensity of the illumination at a surface due to a given source of light is inversely proportional to the square of the distance of the surface from the source of light.

The apparatus consists of a wire frame constructed as illustrated, with a maximum axis of 8 inches. Distances from the source may readily be measured and from the counting of the equal squares the law may readily be formulated. This is a simple pedagogical model which at once brings to the pupil the formulation of a law which oftentimes is particularly abstruse **$1.80**

71–30 CAMERA OBSCURA, or PIN HOLE CAMERA, for illustrating images produced through a small aperture. This camera consists of a rectangular box with pin hole opening in front and a second telescoping box with ground glass plate for receiving the image . . . . . **.65**

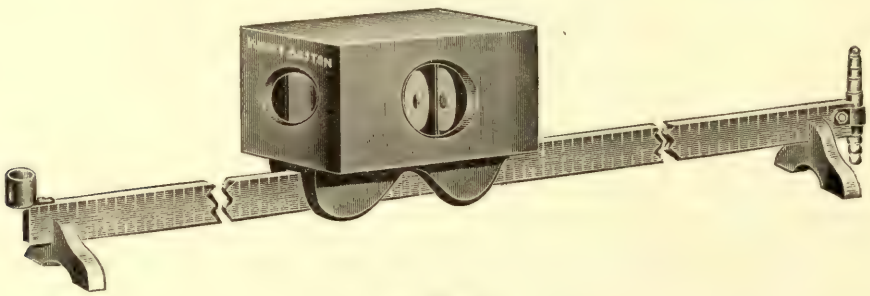


No. 71–40

71–40 **LIGHT-ROOM DIBDIN-BUNSEN PHOTOMETER,** for determining the relative intensity of two sources of light without the necessity of darkening the room.

This improved form consists of a light proof box in which at each end within a separate compartment are situated the sources of light. Between these sources slides the Dibdin-Bunsen Screen, mounted in substantial holder connected as a part of the eye-shade as noted in the illustration and moving with it. This Eye-shade and Screen Holder are fastened at either end by narrow opaque spring-roller-bands attached to the Photometer Box in such a manner as to prevent light from entering the Box. Doors are provided for access to either source of light or to the Dibdin-Bunsen Screen.

Without light sources **$10.50**



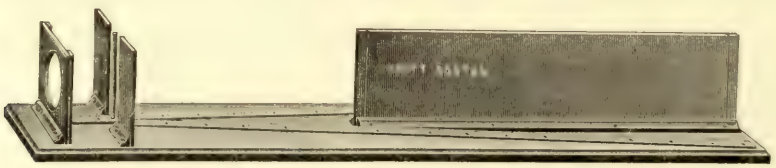
No. 71–50

71–50 **STUDENT'S PHOTOMETER,** for determining by direct comparison with a standard the intensity of a source of light.

The apparatus consists of a graduated rod at one end of which is attached a candle holder; at the other a gas tube with tip. The rod is mounted on metal supports as illustrated in the apparatus of No. **22–160.**

The photometer box with indicator is fitted with a Bunsen screen, Dibdin's modification, placed between two mirrors fixed at such an angle that both sides of the screen can be viewed simultaneously from the front.

This will be found a typical student's instrument, capable of a fair degree of accuracy. Complete as illustrated **$3.50**



No. 71–60

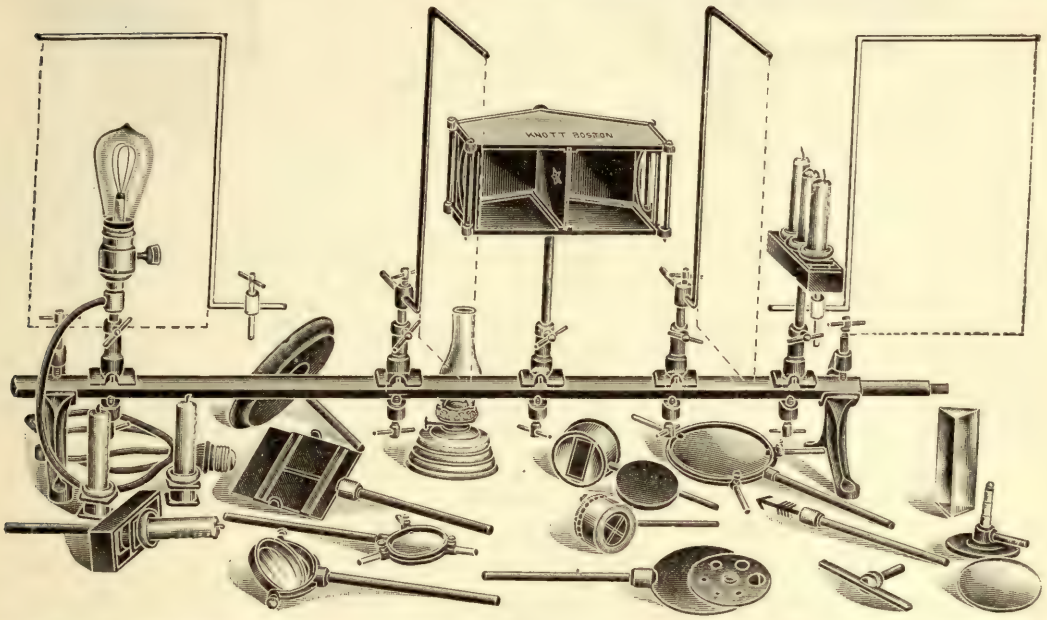
71–60 **RUMFORD'S PHOTOMETER,** for determining the relative intensity of two sources of light.

This Photometer consists of a wooden base board upon which are mounted two converging meter sticks. At the point of convergence is mounted a blackened rod, designed to cast a shadow on the opaque screen held in the vertical support as illustrated at the extreme left hand side. Two screens fixed vertically on either side of the rod are designed for obstruction of all extraneous light. The sources of illumination are mounted on a base board, one on either side of the light shield.

Complete as illustrated **$4.25**

GENERAL PHOTOMETRIC or OPTICAL BENCH ACCESSORIES

PHOTOMETERS



The following accessories are designed for use with "Interchangeable Laboratory Supports" previously listed as follows:

5–55a **SQUARE SUPPORT ROD,** 19 millimeters × 100 centimeters long, graduated to millimeters **$6.50**
5–375 **END SUPPORTS** . . . . . Per Pair **1.00**
5–810 **RIGHT ANGLE CLAMP,** for holding various accessories to the bed-rod . . . . . Each **.85**

PHOTOMETRIC OR OPTICAL BENCHES

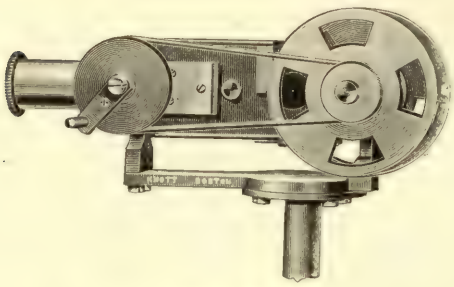
The following outfits may be used equally well for a support for photometric accessories and for general optical accessories.

71–75 **PHOTOMETRIC BENCH.** This bench consists of a pair of No. **5–375** End Supports, 1 Graduated Rod No. **5–55a**, and **5**–No. **5–810** Right Angle Clamps. This outfit will be found sufficient for any photometric experiment.
Complete as listed **$11.75**
71–76 ——, same as above, but Ungraduated Square Rod No. **5–50d** in place of No. **5–55a** Graduated Rod **7.40**
71–78 ——, same outfit as No. **71–75,** but with No. **5–55b** Square Graduated Rod 19 millimeters × 200 centimeters long, in place of No. **5–55a** 100-centimeter Graduated Rod **16.00**
71–79 ——, same as above, but with Ungraduated Rod No. **5–50f** in place of No. **5–55b** Graduated Rod . . **9.60**

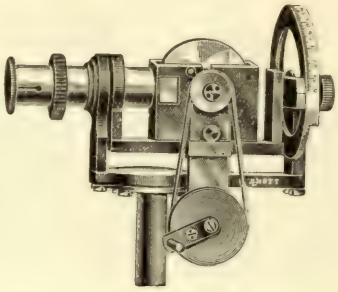
PHOTOMETER SCREENS

71–100 **CAST-METAL DIBDIN-BUNSEN PHOTOMETER,** for use as a comparison head in determining candle power of a source of light.
This photometer is a modification of the standard Bunsen Screen. In the Bunsen Screen the translucent and opaque portions do not transmit light equally. The grease spot, therefore, even when equally illuminated, is never entirely lost. The Dibdin's modification consists in exposing a star of translucent paper mounted in heavier paper of the same texture. This screen is mounted between two mirrors at such an angle within a cast metal box that both sides of the screen may be seen simultaneously. This cast metal box is mounted on a 10-millimeter rod for use with No. **5–810** Clamp. It is blackened inside and out.
The results possible with the Dibdin's modification are accurate and quickly obtained. We desire also to emphasize the advantage of our cast-metal casing over the sheet metal forms **$4.75**

FLICKER PHOTOMETER



No. 71–105



No. 71–106

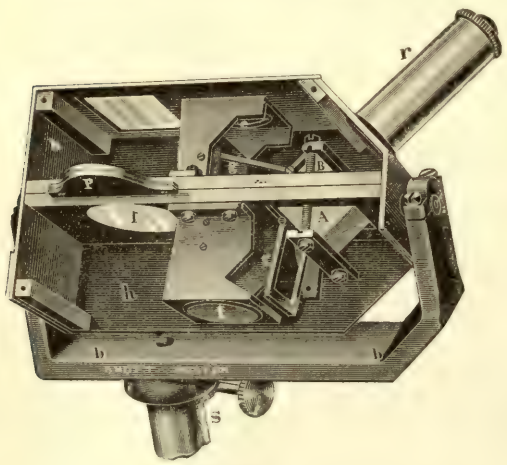
If two flashes of light follow each other sufficiently rapidly, there are no separate sensations perceived, but a running together of the two takes place. If, however, a surface is alternately illuminated by two lights of different brilliancy and the change between the two is not rapid enough to cause them both to coalesce, then the eye perceives the change of intensities as a flickering. If, however, the intensity of illumination is the same in both, no flickering is noticed by the eye.

A flicker photometer utilizes this principle. A flickering arrangement is provided in an instrument as above illustrated, designed to be placed between two lights stationed at the ends of a photometer bench and to be compared with each other. Then, by use of a moderate degree of rapidity in alternating the source of illumination, and, by moving the flickering arrangement toward one of the lights, a position of no flickering is finally secured.

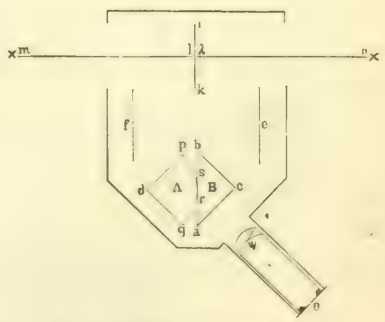
The Flicker Photometer is furnished in two different forms, either with Rotary Discs having Sectional Openings through which the light shines, or with a Rotating Flickering Body. The latter form is provided with an arrangement for inclining the apparatus and with a measuring scale so that one can make measurements in different directions. Both forms, however, have openings furnished with lids in the center of the discs, through which the observer may see that the rays of light fall properly upon the apparatus.

71–105 FLICKER PHOTOMETER provided **with rotary discs having sectional openings** through which the light shines.
Mounted on rod for use with our No. **5–810** Clamp . . . . . Duty Free **$42.00**

71–106 FLICKER PHOTOMETER with rotating flickering body, with hinge for inclining, and with graduated scale for measuring in different directions.
Mounted on rod for use with our No. **5–810** Clamp . . . . . Duty Free **52.50**



No. 71–110



No. 71–110 (Sectional View)

71–110 LUMMER–BRODHUN PHOTOMETER. This is a modification of the grease spot photometer. Light from the two sources falls upon the screen **ik** (see illustration) made of two sheets of paper with tinfoil between, and placed perpendicular to the direction of the optical bench. The diffused light emitted by these screens falls on two totally reflecting prisms and thence on to the faces **bc** and **dp** of the two prisms **A** and **B.** The part **rs** of the prism **A** which touches **B** is plane so that all light falling on **rs** is transmitted. The eye placed at **O** thus receives from the side **m** only light which passes through the ring **rs** and from the side **n** only light which is totally reflected from the surfaces **ar** and **bs.** The eye thus sees a bright or dark spot within a uniformly bright circle. When the photometer is so adjusted that **e** and **f** receive the same amount of light, the round circle of light entirely disappears.
This photometer box is mounted in a frame on rod designed to fit our No. **5–810** clamp for use on an optical bench . . . . . Duty Free **$39.25**

SIMPLE LIGHT SOURCES AND HOLDERS

PARAFFINE CANDLES, for use in photometric work as source of light. These candles are of a standard quality and furnished in two sizes.

70–50a Sixes (6 to the pound) . . . . . Per Dozen **$0.38**

70–50b Twelves (12 to the pound) . . . . . Per Dozen **.20**

OPTICAL BENCH CANDELABRUM AND DRIP CUP, for use with No. **5–810** Clamp as a candle holder on an optical bench " built up " from rods and clamps.

In the design of our Candelabrum we have overcome the objectionable features of the various types on the market. We are enabled to center candles in groups of one, two, three, and four, almost instantly.

This design consists of a cast metal trough mounted on a rod of size for use in No. **5–810** Clamp. The Individual Candle Holders is a casting with drip cup that fits into the trough with a sliding fit. Any or all the Holders may be readily moved laterally in the trough to properly center the light.

71–125 **CANDELABRUM TROUGH,** mounted on a 10-millimeter rod, for use with No. **5–810** Clamp . . **$0.60**

71–127 **INDIVIDUAL CANDLE HOLDER,** for holding candles . . . . . **.15**

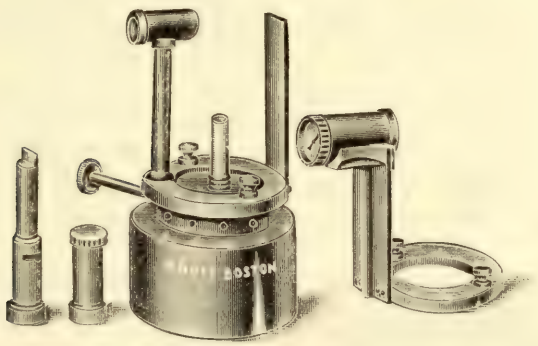
70–72 **BRASS KEROSENE LAMP, WICK, AND CHIMNEY,** for use on table top No. **71–250** . . . . . **.32**

71–135 **LUMINOUS BURNER,** especially designed for use with No. **71–210** T. & H. Light Box with Wire Screen . . . . . **.45**

71–140 **INCANDESCENT LAMP HOLDER,** mounted on rod with attachment for connection to the standard Edison socket.
Without lamp cord and Edison plug **1.20**

FLEXIBLE CORD. See Section **90.**

STANDARD SOURCES OF LIGHT



Nos. 71–159 and 71–160

71–155 **HEFNER LAMP,** approved by the Physikalisch-Technischen Reichsanstalt as the German Photometric Standard Source of Light burning amyl-acetate. **With flame measure,** after regular type, wick regulator and shears . . . . . Duty Free **$12.50**

71–156 ——, same as above, with certificate of the Physikalisch-Technischen Reichsanstalt . . Duty Free **16.50**

71–157 **HEFNER LAMP, with Flame Measure after Hefner-Alteneck,** wick regulator, and shears. Duty Free **12.50**

71–158 ——, same as above, with certificate of the Physikalisch-Technischen Reichsanstalt . . Duty Free **16.50**

71–159 **HEFNER LAMP, with Flame Measure,** after regular type **and also after Hefner-Alteneck,** wick regulator, and shears . . . . . Duty Free **19.50**

71–160 ——, same as above, with certificate of the Physikalisch-Technischen Reichsanstalt . . Duty Free **24.50**

71–161 **AMYL-ACETATE, C. P.,** for burning in the Heffner Lamp . . . . . Per Pound **1.80**

71–165 **STANDARD CANDLE,** for use as photometric standard, made of sperm, six to the pound, will burn 120 grains (7.776 grams) per hour . . . . . Each **.33**

NOTE. No. **71–250** Table Top on Rod is used as holder for above sources of light.

For **Candle Holders** see Nos. **71–125** to **71–127.**

MIRRORS AND MIRROR HOLDERS

71–180 **MOUNTED CONVEX GLASS MIRROR.** This is a convex mirror, 3 inches in diameter, focus 6 inches, adjustably mounted in an improved holder for use with our No. **5–810** Right Angle Clamp **$2.60**

71–182 **MOUNTED CONCAVE GLASS MIRROR.** This is a concave mirror, 3 inches in diameter, focus 6 inches, adjustably mounted in an improved holder for use with our No. **5–810** Right Angle Clamp **2.60**

5–960 **ADJUSTABLE PLANE MIRROR ON ROD,** mirror 50 millimeters in diameter, adjustable in stirrup about a horizontal axis, adjustable on rod about a vertical axis. Mounted on nickel-plated rod 15 centimeters long, for use with our No. **5–810** Clamp **1.95**

MIRRORS. See Section **72.**

LENSES AND LENS HOLDERS

LENSES. See Section **74.**

5–970 **UNIVERSAL LENS HOLDER,** for lenses up to 4 inches in diameter. This ingenious holder is adjustable by means of the rods and set screws to hold and clamp firmly, in or off center, lenses up to 4 inches in diameter. Handsomely oxidized black with nickel-plated rod. (See illustration, Section **5**) **$1.35**

5–975 ——, same as above, for holding lenses up to 2 inches in diameter **1.00**

SCREENS AND SCREEN HOLDERS

71–190 **SCREEN WITH APERTURES.** This is a metal screen on which is mounted a revolving disc with apertures of different sizes. By revolving the disc these various sizes of holes center over the large hole on the screen. It is mounted on a rod ready for use with No. **5–810** Clamp **$3.30**

71–195 **SCREEN WITH ADJUSTABLE VERTICAL SLIT.** This is a metal screen with a two-part metal slide which may be varied at will to secure a slit of any width up to one inch. Mounted on rod ready for use with No. **5–810** Clamp **3.40**

71–200 **SCREEN HOLDER, large size,** for holding large pieces of cardboard, sheet gauze, etc. . . . . **.75**

71–205 **SCREEN HOLDER, small size,** for holding small pieces of cardboard, sheet gauze, etc. . . . . **.65**

71–210 **T. & H. BOX WITH WIRE SCREEN,** for use in determining the conjugate foci of a converging lens. This box is especially designed to hold a source of light. It consists of a metal box in one face of which is a slit covered by a wire screen. It is finished dead black throughout . . . . . **.90**

71–215 **EYE-SHADES,** for use on a photometer bench when it is desired to shade the eyes as well as the front of the screen from rays from the sources of light. They consist of a pair of black cloth shades suitably mounted for use with No. **5–810** Right Angle Clamp **1.80**

71–225 **GRADUATED CARDBOARD SCREEN, 10 × 10 centimeters,** for use with No. **71–200** or **71–205** Screen Holder . . . . . **.10**

71–227 **BLACK OPAQUE SCREEN, 10 × 10 centimeters,** for use with No. **71–200** or **71–205** Screen Holder . . . . . **.20**

71–230 **TRANSLUCENT OR OPALESCENT SCREEN, 20 × 20 centimeters,** for use with No. **71–200** Screen Holder . . . . . **.45**

71–235 **CARDBOARD METRIC SCALES,** for use with No. **71–205** Screen Holder in determining the magnifying power of a convex lens. A 5-centimeter and a 10-centimeter section of a metric scale are mounted on cardboard, the centimeter lines of one ruled in red, in black on the other. Per Pair **.35**

GENERAL ACCESSORIES

71–250 **TABLE TOP ON ROD,** for use with No. **5–810** Right Angle Clamp, as a support for No. **70–72** Brass Kerosene Lamp; No. **71–210** T. & H. Light Box; Prisms, etc. **$1.10**

SUPPORT RODS

5–50d **SQUARE SUPPORT ROD, ungraduated,** 19 millimeters square × 100 centimeters long **2.15**

5–50f ——, same as above, 19 millimeters square × 200 centimeters long **4.35**

5–55a **SQUARE SUPPORT ROD, graduated** to millimeters, 19 millimeters square × 100 centimeters long **6.50**

5–55b ——, same as above, 19 millimeters square × 200 centimeters long **10.75**

5–810 **RIGHT ANGLE CLAMP,** for holding two rods in same plane but at right angles to each other . . **.85**

5–375 **END SUPPORTS,** especially designed for holding bed-rod of optical benches. Extreme care is exercised in machining these supports so that they will suit all requirements. . . . . Per pair **1.00**

LENSES. Section **74**
MIRRORS. Section **72.**
PRISMS. Section **74.**

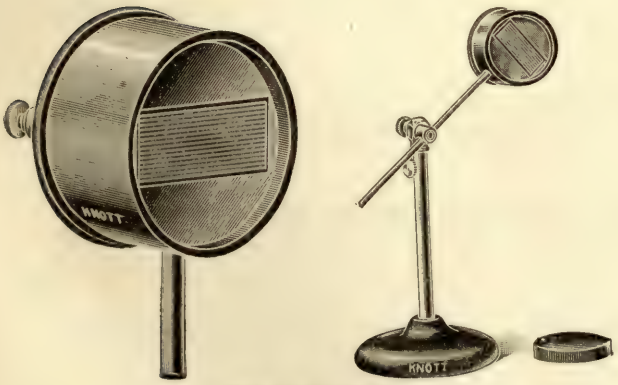
71–300 **BUNSEN PHOTOMETER COMPLETE.** For the convenience of those who are not equipped with "Interchangeable Laboratory Supports" yet who desire a high-grade photometer we list the following rods, clamps, and photometric accessories as set up in the preceding illustration. This outfit is as follows: —

1	No. 5–50d	**Support Rod,** 19 millimeters square × 100 centimeters long.
1 pr.	No. 5–375	**End Supports.**
5	No. 5–810	**Right Angle Clamps.**
1	No. 71–125	**Candelabrum Trough.**
4	No. 71–127	**Individual Candle Holders.**
1	No. 71–100	**Dibdin-Bunsen Photometer on Rod.**
1 pr.	No. 71–215	**Eye-shades.**
1	No. 71–140	**Incandescent Lamp Holder,** but without Lamp.

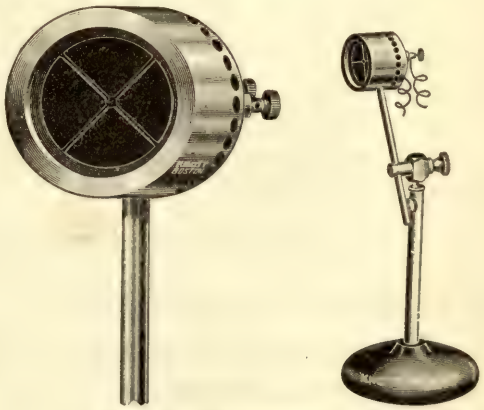
Complete as listed **$16.35**

For those who desire additional sources of light we advise: —

1	No. 70–72	**Kerosene Lamp;**
1	No. 71–250	**Table Top** for supporting same;
1	No. 71–135	**Luminous Burner;**
1	No. 71–125	**Extra Candelabrum Trough;**
4	No. 71–127	**Extra Individual Candle Holders.**



Nos. 71–275 to 71–276



Nos. 64–100 to 64–110

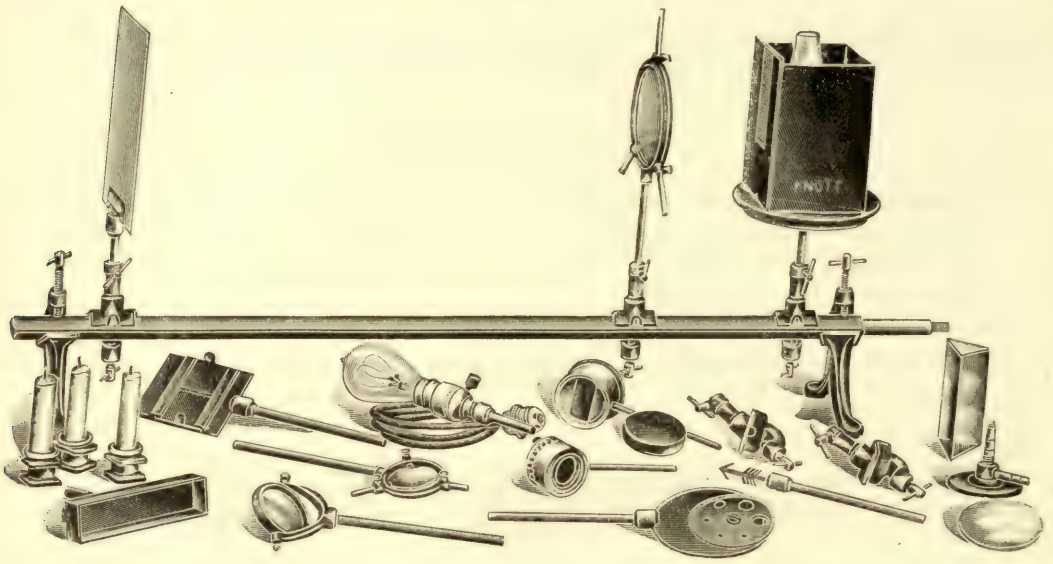
71–275 **SELENIUM CELL,** large. For description see Section **98** **$14.00**

71–276 **SELENIUM CELL,** small. For description see Section **98** **8.50**

64–100 **IMPROVED MINERALITE THERMOPILE "A."** For description see Section **64** **14.50**

64–110 **IMPROVED MINERALITE THERMOPILE "B."** For description see Section **64** **22.00**

OPTICAL BENCHES



For the convenience of those who are not equipped with "Interchangeable Laboratory Supports" yet who desire a high-grade optical bench we list the following outfits of rod, clamps, and accessories.

71–325 **OPTICAL BENCH** as illustrated in above group, accessories arranged in illustration for determining conjugate foci of a double convex lens.

This outfit consists of:

3	**No. 5–810**	**Clamps**
1	**No. 71–210**	**T. & H. Light Box**
1	**No. 71–250**	**Table Top on Rod**
1	**No. 71–200**	**Screen Holder**
1	**No. 5–970**	**Universal Lens Holder**
1	**No. 71–230**	**Translucent Screen**
1	**No. 5–55a**	**Square Support Rod,** 19 millimeters square × 100 centimeters long, graduated to millimeters.
1 pr.	**No. 5–375**	**End Supports**

Complete as above described **$14.60**

71–326 **OPTICAL BENCH,** as above described, but with No. **5–50d** Ungraduated Support Rod, 19 millimeters square × 100 centimeters long, in place of No. **5–55a** Graduated Rod **$10.25**

SOURCES OF LIGHT FOR USE ON ABOVE BENCHES

71–127 **INDIVIDUAL CANDLE HOLDER** **$0.15**

70–72 **KEROSENE LAMP WITH WICK AND CHIMNEY** . . . . . **.32**

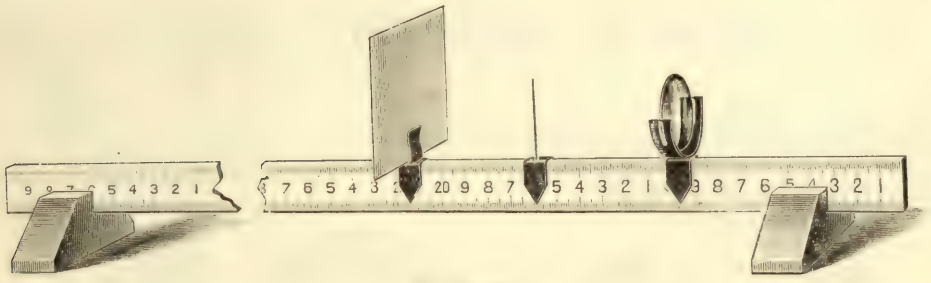
71–135 **LUMINOUS BURNER** . . . . . **.45**

71–140 **INCANDESCENT LAMP HOLDER,** without Lamp **1.20**

71–328 **OPTICAL BENCH,** same as No. **71–326,** but with No. **5–50f** Support Rod, 19 millimeters square × 200 centimeters long, in place of No. **5–50d,** 100 centimeters long **12.45**

71–330 ——, same as No. **71–325,** but with No. **5–55b** Support Rod, 200 centimeters long, in place of No. **5–55a,** 100 centimeters long **18.85**

STUDENTS' OPTICAL BENCH



No. 71–350

71–350 STUDENTS' OPTICAL BENCH, a simple outfit for optical experiments by students.
This bench consists of a meter stick which is fixed in a horizontal position by means of our new design of end supports, as may be seen illustrated under No. **22–160.**
The various accessories which we list under this number will be found necessary in the study of the standard experiments, usually in the study of lenses, etc.
The apparatus is shipped complete with meter stick, a lens holder, one lens with finished edges, 1½ inches diameter, 15 centimeters focus, a pin holder, pair of metal supports for meter stick, screen holder, and cardboard screen. This will be found a very convenient and useful laboratory outfit **$1.25**

11–10 METER STICK . . . . . **.30**

71–352 LENS HOLDER . . . . . **.22**

74–121 LENS, 1½ inches diameter, 6 inches focus . . . . . **.20**

22–160b METAL SUPPORTS FOR METER STICK . . . . . Per Pair **.25**

71–356 SCREEN HOLDER . . . . . **.12**

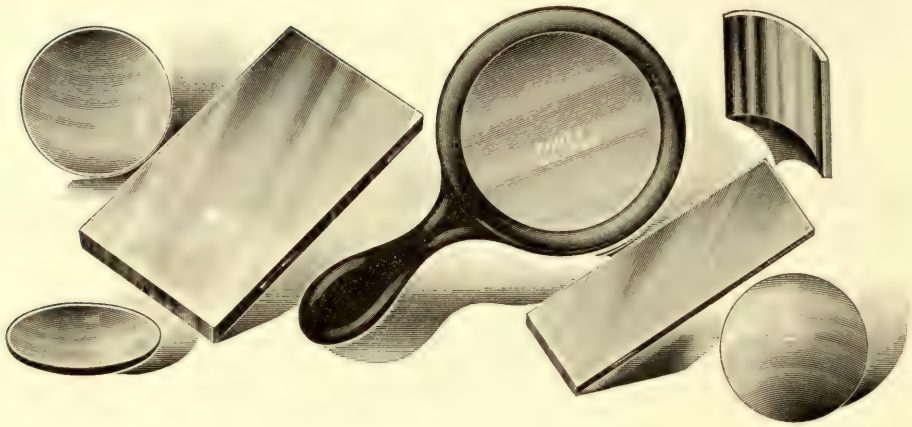
71–225 GRADUATED CARDBOARD SCREEN . . . . . **.10**

71–358 PIN HOLDER . . . . . **.10**

71–375 MOUNTED BENT WIRE, for finding real and virtual images in a lens.
This is the standard piece so frequently called for in the many manuals in use among secondary schools . . . . . **.20**

REFLECTION OF LIGHT

MIRRORS



Nos. 72–10 to 72–45

72–10 PLANE GLASS MIRROR, for experiments in reflection of light. Best German glass, 6 inches long by 2 inches wide . . . . . Each **$0.12**

72–12 PLANE MIRROR, similar to above, but 6 inches × 4 inches . . . . . Each **.20**

72–20 CONCAVE AND CONVEX CYLINDRICAL MIRROR. This is a cylindrical brass mirror, carefully burnished on both sides and heavily nickel-plated. One side is concave and the other convex. Each **.50**

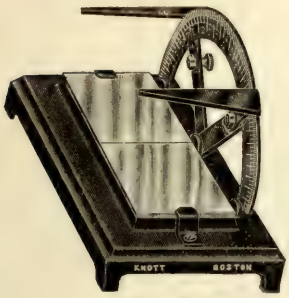
72–25 CONCAVE AND CONVEX SPHERICAL MIRROR. This is a spherical mirror of brass, 3 inches in diameter, 6-inch focus. It is carefully burnished and nickel-plated on each side, one side convex and the other concave . . . . . **.50**

72–35 CONVEX MIRROR. This is a carefully silvered glass mirror with a protective coating. It is 3 inches in diameter, with a focus of 6 inches **1.25**

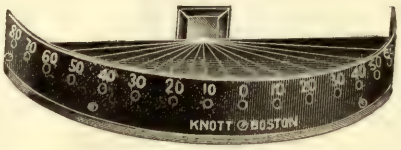
72–37 CONCAVE MIRROR. This is a carefully silvered glass mirror with a protective coating. It is 3 inches in diameter, with a focus of 6 inches **1.25**

72–45 MOUNTED CONCAVE AND CONVEX MIRROR. This instrument consists of two mirrors, one concave, the other convex, mounted in a circular wooden frame, with handle; diameter 5 inches **2.25**

INCIDENCE AND REFLECTION APPARATUS



No. 72–60



No. 72–70

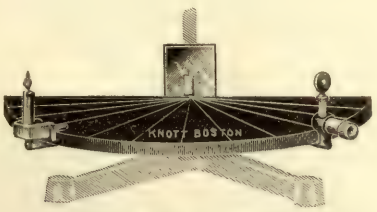
72–60 IMPROVED INCIDENCE AND REFLECTION APPARATUS, for determining the law of reflection of light. This design consists of a smooth metal casting, to a " boss " on which is attached a divided arc; the center of this " boss " is in the same plane as the etched mark on the reflecting surface. Swiveled at this point also are two cast metal arms. These metal arms extend over the divided arc to form a line of sight to the mirror. Their edges are beveled to facilitate this reading. By means of thumb screws both these arms may be clamped in positions desired.

In use, one arm is set at any desired position. Sighting across the second, this arm is moved until the image of the first and the etched line of the mirror and the sighting edge of the second are in the same straight line. If the positions of these index arms are noted on the graduated arc it will be found that the Angle of Incidence is equal to the Angle of Reflection **$2.25**

72–70 GAGE'S REFLECTION APPARATUS, for demonstrating the law of reflection of light.

This apparatus consists of a semi-circular board at the center of the circle of which is a mirror mounted vertically. A metal strip with holes drilled every ten degrees is mounted as illustrated to the rim of this board.

By glancing in the mirror through the hole marked " O " an image only of the hole is seen. If the source of light is held before any of the other holes the image in the mirror can be seen only through the hole equally distant on the other side of the normal to the mirror **1.50**

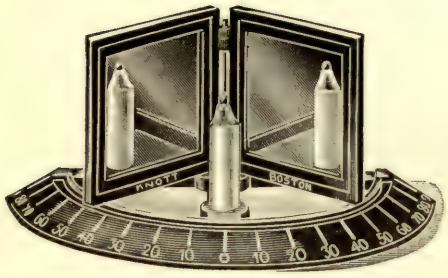


No. 22–145

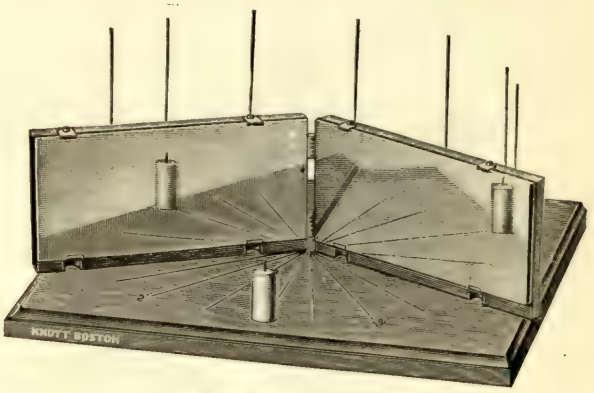
22–145 INCIDENCE AND REFLECTION APPARATUS. The apparatus illustrated consists of an attachment for our Universal Stand No. **22–130.** This design consists of a semi-circular board, the top surface of which is divided into equal sectors, and it is provided with clamp for attaching to the 19-millimeter rod. To the under side of this board are swiveled two arms with up-turned ends, one of which is provided with a sight hole; the other with a candle holder.

In use, the candle is placed in the holder and trimmed so that its flame may be on the plane with the sight hole. It is then lighted. The arm for carrying the sight hole is moved along until the rays of the candle flame are seen through the sight hole. By a glance at the sector line it will be found that this Line of Reflection makes the same angle with the normal to mirror as the Line of Incidence makes with this perpendicular, thus proving that the Angle of Reflection is equal to the Angle of Incidence **$6.65**

MULTIPLE REFLECTION APPARATUS



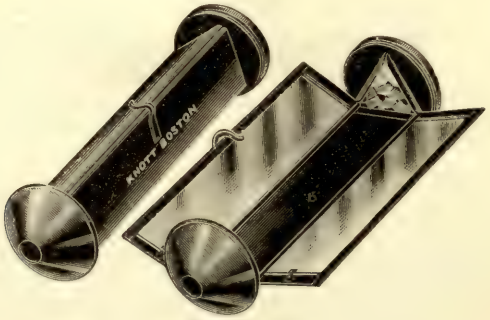
No. 72–90



No. 72–95

72–90 MULTIPLE REFLECTION APPARATUS, for illustrating the phenomenon of multiple reflection.
This apparatus consists of a handsomely finished metal casting on which are degree lines denoting every ten degrees. Two mirrors, mounted on appropriate metal frames and hinged at the centre of the circle, are movable within 180°. In this casting a candle holder is provided for holding the candle in the best possible position. A further advantage of this model is that the mirrors may be unhinged from the centre and mounted parallel, thus showing the infinite number of images that may be formed in mirrors mounted parallel to each other.
The results possible with the use of a multiple image apparatus are very strikingly shown with this instrument. With the mirrors placed at an angle of 45° a class can see that seven images are formed; at 60°, five, the number of images increasing as the angle diminishes.
Complete as illustrated **$7.50**

72–95 MULTIPLE IMAGE APPARATUS, after Hall & Bergen's " A Text-Book of Physics," page 158.
This apparatus consists of a board in which are drilled thirteen holes, appropriately placed for the accurate formulation and demonstration of the law of multiple images. Two hinged mirrors neatly mounted in frames may be moved to any position on this board.
In use the mirror is placed upon the board with the reflecting surfaces making an angle of 90°, — in the position as illustrated. The lighted candle should be of such height that its flame will not be above the upper edge of the mirrors and should be exactly over the middle hole in front of the board. The positions of the images of the candle should now be noted and pegs placed into the holes behind the mirrors in such a position that, to an observer placed in front of the mirrors, the images in the mirrors and the pegs over the mirror will appear to coincide with the images. The experiment should be modified with the mirrors at angles of 60° and 30° also.
This instrument will be found capable of a pedagogic value in excess of many other designs on the market **3.25**

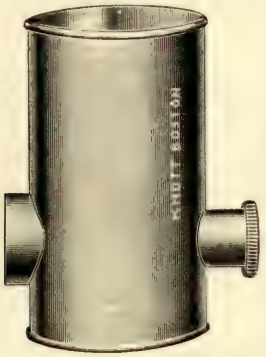


No. 72–100

72–100 KALEIDOSCOPE. This apparatus is a design of our own and consists of 3 mirrors, each separately mounted in a metal frame and combined to form a case with mirrors at an angle of 60°. One end is closed by a disc of ground glass, the other is provided with a cap with an aperture. Fragments of colored glass are placed at one end between the ground glass discs and the second clear glass disc. The objects and their images when viewed through the aperture present themselves in an endless variety of symmetrical forms as the Kaleidoscope tube is turned **$2.75**

72–105 STUDENTS' KALEIDOSCOPE, similar in design to above, but of simpler construction . . . . . **.48**

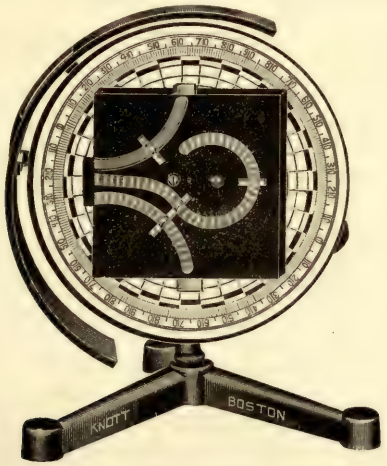
TOTAL REFLECTION APPARATUS



No. 72–125

72–125 LUMINOUS CASCADE, used with a strong source of light and a condenser for showing total reflection by means of a jet of water. The cylindrical vessel illustrated is placed in front of the source of light in such a way that the glass disc is parallel to, and about 2 centimeters from, the condenser. Water as pure as possible is poured into the vessel and allowed to issue from the jet orifice. The stream of water is then seen to be illuminated for a considerable distance.

A pleasing modification of this experiment is to insert colored glass plates between the condenser and the window of the vessel . . . . . Duty Free **$4.80**



No. 72–140

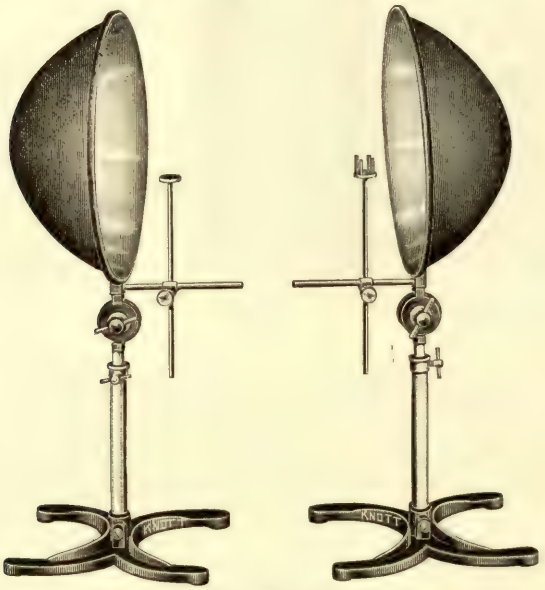
72–140 OPTICAL DISC TOTAL REFLECTION APPARATUS, for showing total reflection in glass rods; also illustrating the Luminous Cascade.

The apparatus consists of a dull black board designed for attachment to the face of the Optical Disc as illustrated. On the board are mounted three bent glass rods, one of which is smooth, the other two covered with small chinks of glass. The ends of these rods pass through a diaphragm on which the light falls. Light, therefore, enters these rods through the ends. The effect is readily noticeable. The smooth rod remains dark, while the ones with small chinks glisten with bright light. The light, however, in the smooth rod, being conveyed further by total reflection, passes out in nearly full strength upon a screen mounted to the face of the board: on the other hand, the spot of light received on the screen from the rod with small chinks is noticeably fainter inasmuch as the light in the rod has partially passed out through the chinks in the walls causing the glistening bright light.

This experiment is extremely effective when colored light is used. It has distinct advantages over the Luminous Cascade No. **72–125** in that the observations of the experimenter are not disturbed by the necessity of catching the water and refilling the apparatus.

Complete ready for attachment to face of Optical Disc . . . . . Duty Free **$10.50**

PARABOLIC REFLECTORS



No. 52–10

52–10 THIRTEEN-INCH UNIVERSALLY ADJUSTABLE TRUE PARABOLIC REFLECTORS, for demonstrating Reflection of Sound, Heat, and Light Waves.

In offering for sale our Improved Reflectors we desire to emphasize the **TRUE PARABOLIC SURFACES.** The curves of these surfaces have been accurately calculated and drawn and then by painstaking processes a chuck has been turned to the true parabolic curve. Our Reflectors are all spun from this chuck. The reflecting surface is then highly polished and heavily nickel-plated, presenting an excellent surface without waves.

The Reflectors are mounted in a two-part circular casting in such a manner as to entirely obviate any danger of distorting the surfaces. This two-part casting is brought together at the bottom, where it makes a swivel junction with a rod telescoping into the supporting base.

The holders and attachments are all of special design which allow of both coarse and fine adjustments. We, therefore, secure a tilting movement for the Reflectors, an adjustment for proper height, and universal movements for each attachment.

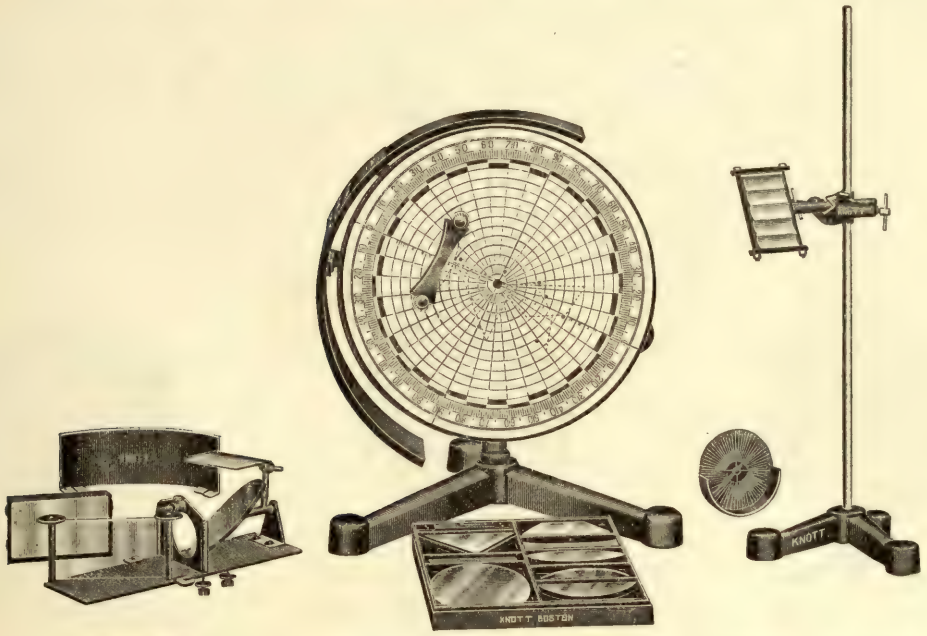
With this shape of mirror all rays of light can be brought from an infinitely distant object to a point focus and, when the source of light is placed in the focus, the rays incident on the reflecting surface are reflected exactly parallel to the axis. The light thus reflected tends to maintain its intensity at a great distance. Thus a candle may be mounted on one of the carriers at the focus of one mirror; if now another reflector be directed toward the first it may be demonstrated that the rays will be brought to a focus. If a piece of inflammable material such as phosphorus be placed at the focus of the second reflector it may be demonstrated that the heat waves are also brought to a focus by causing the phosphorus to burn.

The finish of this instrument is fully in keeping with the design. The outer surfaces of the Reflectors are dull oxidized, the H-base bright japan, and all brass parts polished and nickel-plated.

Thirteen-Inch Universally Adjustable True Parabolic Reflectors complete as illustrated with attachments . . . . . Per Pair **$17.50**

52–15 ——, same as above, mounted on stand but without attachments or carriers . . . . . Per Pair **13.50**

KOLBE'S OPTICAL DISC AND ACCESSORIES



No. 73–80 No. 73–10 No. 73–75 No. 73–50

73–10 KOLBE'S UNIVERSAL INCLINATION OPTICAL DISC. The optical disc has without question given more universal satisfaction than any other single demonstration apparatus. In fact, its utility has become so great that in the study of Optics it has become practically indispensable. With its use, problems in refractions and reflections are made easy of comprehension. Designed primarily as a lecture table instrument, the simplicity and facility of use and the clearness with which results are obtained and comprehended have made it an important laboratory instrument for students' use as well.

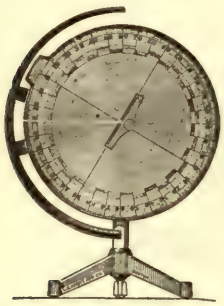
The Optical Disc is self-contained in that no accessory except that of a strong source of light is required. Sunlight, either direct or reflected, gives the best results in that the beam of light obtained consists of parallel rays. The results are readily possible, however, with any source of light, — projection lamp, incandescent mantle, etc., even light from an electric bulb or gas flame being sufficiently strong for a number of experiments. With a strong source of light the instrument may be used in a room flooded with light, many teachers using the instrument in direct sunlight coming through the window.

Our instrument has been greatly modified to incorporate the improvements which in our experience have seemed advisable. The illustration above does not convey the true idea of the qualities of our improved model. Our stand has been entirely redesigned, we desiring to secure a greater stability and greater range of usefulness of the disc itself as well as to correct the annoyances found in the old types. The base of our modified instrument is a heavy casting, with **recessed pockets for each of the various glass parts.** This will be noted as a great convenience by teachers who have been unable to locate readily different glass parts which have been desired. To the upright of this metal casting is mounted the disc 13 inches in diameter, the face covered by a dial with water-proof finish. By a **special toothed casting** to which the disc is attached and which swivels at the top of the upright we are enabled to obtain a **universal inclination** for the face of the disc. Thus we are enabled to secure a vertical position or a true horizontal position and intermediate positions, the position being locked in place by means of a pin which meshes with the teeth.

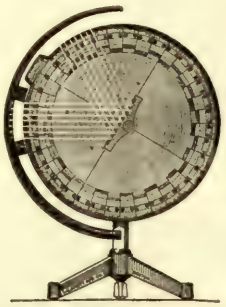
A further improvement in our design consists in the method with which we attach the shade to our stand. In the old forms the shade is held on the rod to which is fastened the disc, and is held by friction by means of a spring washer. The trouble with this construction has been that neither disc nor eye-shade could be turned without moving the other. By means of our improvement the **shade works on the hub of the toothed casting** above described. The disc attached to a rod is free to move on its own axis; thus it works entirely independent of the other.

The dial on the face of this disc has improved graduations which are large and quite distinct that they may be seen by the pupils even in the rear of the lecture hall. At various positions on the face of this disc are diagrams representing the different glass parts. In use of these it is only necessary to place them over the diagram and fasten them to the face of the disc by means of thumb nuts in the bushed holes threaded in proper places in the face of the disc. The source of light enters through slits in a screen provided in the shade. By means of metal pieces one is enabled to regulate the number of slits from one to seven. Small clips are provided for holding these metal pieces as well as for holding colored glass strips which are used in study of total reflections in prisms and in the study of retardations to colored lights.

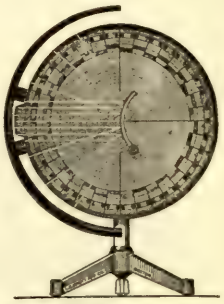
The various optical parts which are furnished with the instrument represent in section different lenses, prisms, and mirrors. We desire to call particular attention to the type furnished with the Kolbe Optical Disc. Each optical part is of clear glass with no bubbles. That the beam of light may readily be traced through the glass, the back is coated with a white, hard enamel, evenly spread and which offers a durable coating that will not peel.



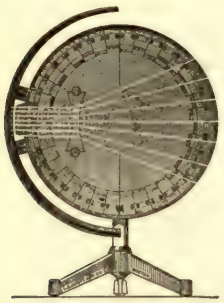
A ray reflected from a plane mirror. Angle of incidence equal to angle of reflection.



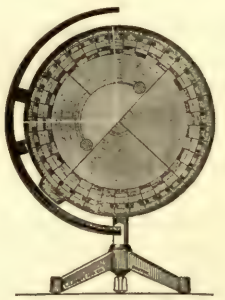
Reflection from a plane mirror. Incident parallel rays are reflected parallel.



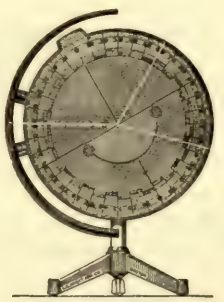
Reflection from a convex mirror. Showing divergence of rays.



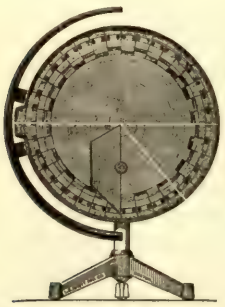
Refraction through double concave lens. Showing divergence of rays.



Ray totally reflected. By turning disc, critical angle may be determined.

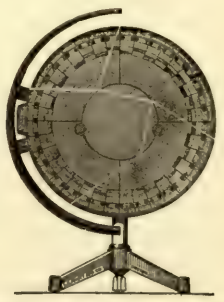


Ray partly reflected, partly refracted. Showing angle of incidence and refraction.



One-half of ray refracted. Showing angle of refraction.

Convergence of diverging rays by double convex lens.



Theory of the rainbow. Showing the "Primary Bow."

The complete optical outfit consists of a plane, a convex, and a concave mirror, a Porro's and a total reflection prism, a double convex and a double concave lens, and a rainbow disc. In addition there are furnished three different colored glasses and two metal strips for use with the screens.

Kolbe Universal Inclination Optical Disc complete **$16.50**

73–50 DIVERGING RAY ATTACHMENT, for use with the Kolbe Optical Disc in securing diverging rays of light in the study of effects of various optical parts furnished with the Optical Disc upon diverging rays.

This instrument illustrated in group with Optical Disc consists of a system of concavo-cylindrical lenses mounted in a frame and adjustably supported in a clamp on a tripod stand.

In use the concave surfaces should be directed toward the source of light. Each individual lens sends out a bundle of diverging rays and one ray from each lens will pass through the slit in the screen forming a system of rays which appear to come from the slit as a source and cross the disc.

Diverging Rays Attachment **$5.50**

73–75 REFRACTION TANK, for study of refractions in water and for determining the index of refraction of any liquid inactive upon the metal.

This attachment which fastens to the center of the Kolbe Optical Disc consists of a circular tank with glass front. This glass covers slightly more than one-half circle so that the water level may be used at the 90–90 mark. That results may be quantitatively made the whole-circle back is graduated.

In use the tank is attached to the face of the disc and filled to the 90–90 degree line with the liquid to be studied. A ray of light is then allowed to strike the surface of the liquid. This ray traces a path through the liquid which may be read through it. From the Angle of Incidence read from the face of the disc and Angle of Refraction read from the graduated circular back the Index of Refraction of the Liquid may be determined.

Refraction Tank ready for use on disc **3.90**

73–80 POLARIZED LIGHT ATTACHMENT, for fastening to face of the Optical Disc in studying phenomena of Polarized Light; — uniform reflection of ordinary unpolarized light, polarization by reflection, polarization by repeated refractions, chromatic polarizations, etc.

All parts of this attachment are fastened to a rectangular metal plate which in use is held to the face of the Disc by means of thumb screws. Thus there will be found the holder for the polarizers, — the plate glass slab and the glass plate bundle: at the other end is the Analyzer, — a heavy black plate glass slab held at proper inclination and position in a special holder which permits of rotary motion. To the same holder is attached the projection screen in rotary adjustment. Between Analyzer and Polarizer is situated the stage provided with simple holder for specimens for study under polarized light.

Attachment complete with thumb screws for attaching to face of Optical Disc and with a sheet metal screen for completely shadowing the projection screen **8.25**

73–100 STUDENT'S OPTICAL DISC. Frequent calls have been made for a design of optical disc simpler than the one previously described. In the model which we list the same optical parts are furnished as are furnished with the above outfit. We have, however, greatly simplified our stand, limiting, of course, the utility of the instrument in all positions. Only the horizontal position can be obtained with this design. The number of experiments possible with this outfit is fully described in the National Physics Note-Book Sheets, this being a design especially adapted to these experiments. Full list of the printed direction sheets furnished with each instrument.

Complete with all optical parts **12.75**

73–101 STUDENT'S OPTICAL DISC without optical parts **7.25**

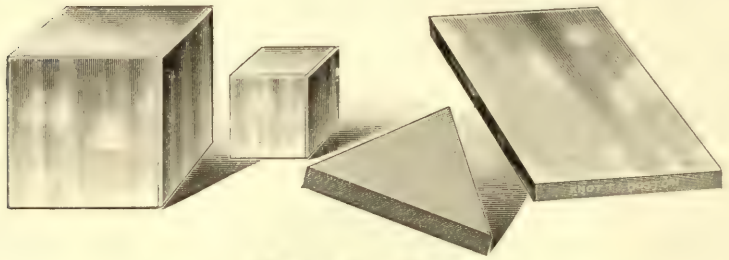
73–102 STUDENT'S OPTICAL DISC GLASS PARTS, as described and illustrated in No. **73–10** **5.50**

One set No. **73–102** parts will be found sufficient for four groups of students.

73–105 INCANDESCENT LAMP WITH SHIELD, for 110 volt D.C. or A.C., special T. & H. form . . . **1.40**

REFRACTION OF LIGHT

INDEX OF REFRACTION OF SOLIDS



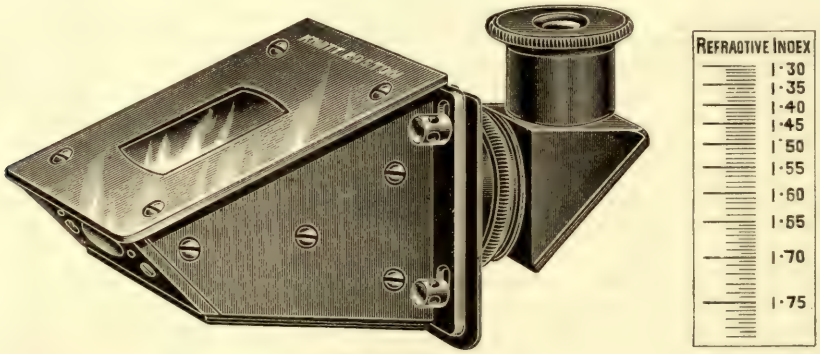
Nos. 74–50 to 74–62

74–50 **INDEX OF REFRACTION PLATE, GILLEY FORM,** for determining the index of refraction of glass. This is a standard glass index of refraction plate, universally described in text books and manuals. Dimensions, 3 × 4 inches. Polished edges **$0.27**

74–55 **EQUILATERAL PRISM,** after Millikan & Gale's "A Laboratory Course in Physics," Experiment 43. This is a triangular prism of heavy glass plate, 75-millimeter edge. Edges polished . . . . **.80**

74–60 **GLASS CUBE** for the determination of the index of refraction of glass. Polished faces, 30-millimeter edge . . . . . **.40**

74–62 ——, same as above, but 50-millimeter edge . . . . . **.80**



No. 74–70

74–70 **DIRECT READING SOLIDS' REFRACTOMETER,** for determining the refractive indices of translucent solid substances by means of the principle of total reflection.

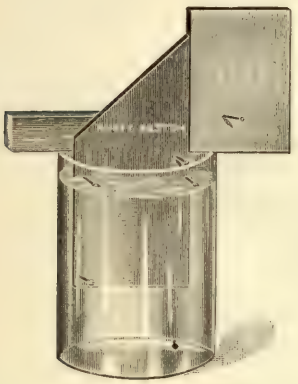
This instrument consists of a hemisphere of very dense glass, mounted in a frame-work and attached to an optical system. It is so arranged that light, entering on one side of the hemispherical lens, after reflection, emerges from the other side and falls upon a transparent scale where it is viewed through the eye-piece of the instrument. The range of the instrument extends from 1.320 to 1.795 and the refractive index within this range of any solid or translucent substance can be determined instantly without calculation directly to the second place and by estimation to the third place of decimals.

The instrument is so constructed that it will accommodate very large or small specimens, a surface of 1 millimeter square being the smallest effective area.

For the purpose of excluding air from between the surfaces of the hemisphere and the subject under examination, a highly refracting liquid is used.

Complete with descriptive pamphlet, 15 grams each of two special liquids, in mahogany box. Duty Free **$55.00**

INDEX OF REFRACTION OF LIQUIDS



No. 74–75

No. 74–80

74–75 GILLEY INDEX OF REFRACTION OF WATER BOARD, for determining the index of refraction of water.

This apparatus consists of a thin board attached to a cross-head. The cross-head is of the size and length to hold the board perpendicular in the jar of water. The line of sight as well as the water level is determined by means of pins. Without Jar $0.75

31–265c GLASS JAR for above, 6 × 8 inches 40

74–80 INDEX OF REFRACTION OF WATER APPARATUS, HALL AND BERGEN FORM, for determining the index of refraction of water.

This apparatus consists of a brass partition with attached clamps for holding it to the jar adjustable to the height of the water in the jar; one brass piece, which may be clamped to the side of the jar, serves as an index pointer for determining the line of sight. Complete with Jar 80

74–81 BRASS PARTITION with attached clamps 20

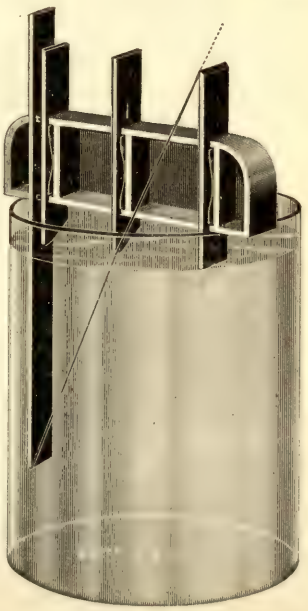
74–82 BRASS CLAMPS with index points . . . . . Each .20

31–265c GLASS JAR, 6 × 8 inches 40

74–90 PRATT INSTITUTE INDEX OF REFRACTION APPARATUS, for determination of Index of Refraction of Water.

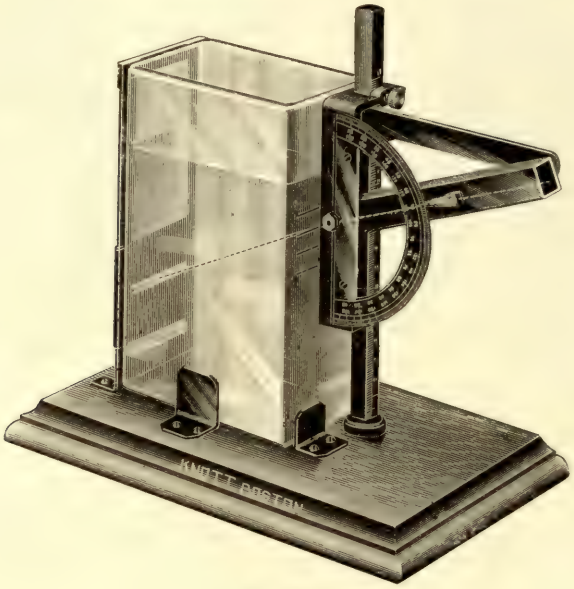
This instrument consists of a metal casting holding a metal strip with spring grip in each of the four slots. The lower ends of the two inner strips are intended to give the line of water, the strip at right of the illustration, to give the angle of incidence. In use the lower end of this strip touches the water line, the line of sight starting over the beveled top. The fourth strip is adjusted to give the line of refraction. Beginning with the strip at the left, then, the line of sight is over the top of the first across the bottom of the second to the bottom of the fourth. When these points are obtained the instrument is taken from the jar and the straight edges placed on a sheet of paper and the line of sight drawn. Index may be determined by ordinary geometrical method or the sines of the angles obtained may be secured from any logarithmic table.

The simplicity of this instrument will appeal to all. The facility of use, scientific observation of details and appearance will doubtless be noted. Without Jar $1.90



No. 74–90

INDEX OF REFRACTION OF LIQUIDS



No. 74–92

74–92 UNIVERSAL DIRECT READING INDEX OF REFRACTION APPARATUS, for determining the index of refraction of any colorless liquid, — acid or alkali.

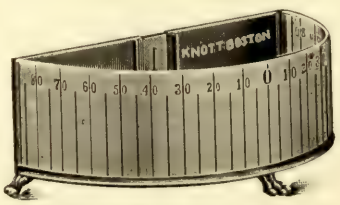
This instrument consists of a base on which is mounted a graduated rod. On this rod is fitted a frame, free to move up and down the rod, and which may be clamped wherever desired by means of set screws. To this frame are attached an arc and a side tube with cross-wire. This side tube is swiveled at the center of the arc. A clear glass jar is held to the base, close up to the frame, by means of spring clips fastened to the base. The side nearest the arc has engraved on its face four lines. The opposite side is provided with a metal frame on which slides a screen with movable slit. The line of sight, therefore, is from the cross-wire inside of the tube through the tube through one of the lines engraved on the jar to the slit on the opposite side of the jar.

The apparatus is accurately constructed, graduations clear and distinct, handsomely finished.

Three methods of determining the index of refraction of a liquid are possible:

1. Index of Refraction may be read from the arc, and the sines of the angles from any logarithm table.
2. Length of the sines may be read directly by means of the sliding index on the graduated rod.
3. The index may be determined by the usual geometrical construction of the angles to the mensuration of the sines.

Apparatus complete as illustrated, furnished with simple laboratory directions **$4.30**



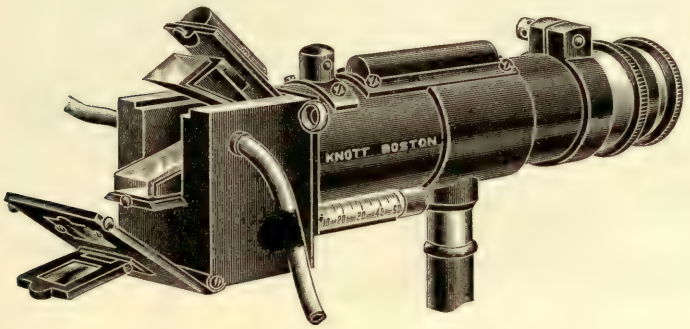
No. 74–95

74–95 REFRACTION TANK, for experiments on refraction at plane surfaces.

This tank consists of a semi-circular vessel of glass, one side of which is curved, and the other side opaque except for the slit through which the light may enter the tank. The reading of the path of the light may be made when the tank is empty.

This is an interesting and instructive experiment and the apparatus is sufficient in size for use in lecture experiments **$8.00**

DIRECT READING LIQUID REFRACTOMETER



No. 74–100

74–100 DIRECT READING LIQUID REFRACTOMETER, for determining the refractive indices of liquids.

This apparatus consists of a metal box containing two prisms between the surfaces of which the liquid under examination is placed. The light passing through the prisms is viewed through a telescope attached to the prism box. The telescope is provided with a transparent scale of the refractive indices which is examined by a high power eye-piece. Owing to the indices of the liquids changing rapidly with variations of temperature, the prism box is so constructed that a stream of water can be caused to circulate around the prisms by means of a water circulation apparatus, thus regulating the temperature and keeping it uniform during an observation. A thermometer inserted in the box indicates the degree of heat. The prisms are so arranged that both can be readily removed for cleaning. In use, a drop of the liquid to be tested is placed in the center of the exposed face of the lower prism. The upper face is folded down and at the same time the hinged flap containing a window through which the light enters, is turned until it is secured by the catch. An adjustment is provided to the upper prism so that when folded down, the intervening liquid is spread into an even film.

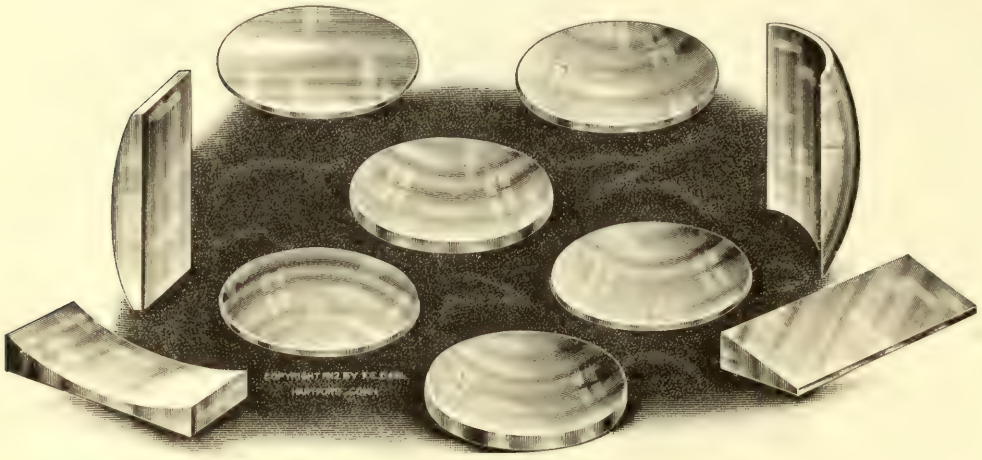
The scale gives the refractive indices for sodium light at 15 degrees Centigrade. Observations may be made in daylight, and for this purpose a tinted glass is provided which destroys the colored edges of the shadow.

This instrument is provided with two scales, one extending from 1.3200 to 1.4200 and the other from 1.4300 to 1.5300. In either case the indices are read directly without calculations to the third place of decimals and by estimation to the fourth place.

Direct Reading Liquid Refractometer, Scale 1.3200 to 1.4200. In case . . . . . Duty Free **$74.75**

74–101 DIRECT READING LIQUID REFRACTOMETER, Scale 1.4300 to 1.5300. In case . Duty Free **74.75**

DEMONSTRATION LENSES



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No. 74–107

74–107 **DEMONSTRATION LENSES.** A set of 10 lenses each 3 inches in diameter.
These lenses include one each of the following types:

Double convex, double concave — **Cylindrical convex, cylindrical concave**
Plano convex, plano concave — **Sphero-cylindrical, sphero-prismatic**
Periscopic convex, periscopic concave

The complete set of 10 lenses, 3 inches in diameter **$7.50**

74–110 **DEMONSTRATION LENSES.** Set including one each of the following lenses:

Double convex, double concave — **Plano-convex, plano-concave**
Periscopic convex, periscopic concave

Set of 6 lenses, 2 inches in diameter, in box **2.50**

74–112 ——, set of 6 lenses, same as above, 1½ inches in diameter, enclosed in cardboard box **1.25**

No. 74–115

74–115 **PHYSICAL LABORATORY TEST LENSES,** a set of positive and negative lenses, 38 millimeters in diameter, enclosed in special lined case, each in separate compartment.
Set comprises 30 lenses as follows: ± 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18 and 20 diopters.
Duty Free **$15.50**

74–116 ——, same as above, but with only eight lenses as follows: 2, 4, 5, 8, 10, 20, −5 and −10 diopters.
Duty Free **7.75**

LABORATORY LENSES

DOUBLE CONVEX LENSES, highest quality, carefully polished, ground edges.

Number	74–118	74–120	74–121	74–122	74–123	74–124	74–125	74–126
Diameter	1½	1½	1½	2	2½	3	4	4 inches
Focus	2	4	6	5	6	7	10	16 inches
Each	$0.50	0.30	0.20	0.55	0.68	0.95	1.50	1.80

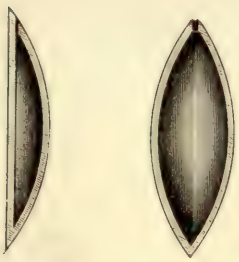
DOUBLE CONCAVE LENSES, highest quality, carefully polished, ground edges.

Number	74–150	74–151	74–152	74–153
Diameter	1½	1½	2	3 inches
Focus	6	8	8	6 inches
Each	$0.40	0.50	0.65	1.75

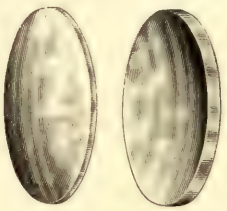
CONDENSING LENSES, plano convex, highest quality, carefully polished, ground edges.

Number	74–170	74–171	74–172	74–173
Diameter	4½	4½	5	6 inches
Focus	6½	10	8	10 inches
Each	$1.60	1.35	2.00	6.00

MISCELLANEOUS LENSES



No. 74–180 No. 74–182



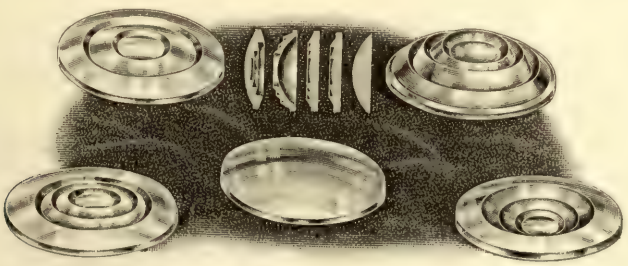
No. 74–190

74–180 WATER LENS. This is a hollow plano-convex vessel, with opening for introduction of water. Diameter 80 millimeters $3.90

74–182 WATER LENS. This is a hollow double convex vessel, with opening for introduction of water. Diameter 80 millimeters 3.90

74–190 DEMONSTRATION ACHROMATIC LENS. This lens, in reality, consists of 2 lenses, a concave and a convex lens, each 1½ inches in diameter, accurately ground to fit each other. Achromatism positive . . . . . Per Pair .75

74–192 ACHROMATIC LENS, consisting of two lenses, a diverging concavo-convex flint glass lens and a double convex crown glass lens, accurately ground and polished, and perfectly fitted to each other. Diameter 2 inches, focus 8 inches 6.80

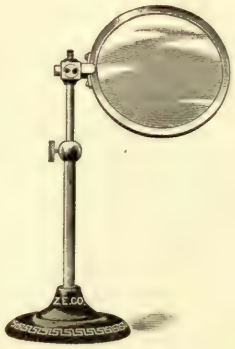


No. 74–200

74–200 PRISMATIC LENSES. This set of lenses is brought to the attention recommended as a demonstration set illustrating the various forms of commercial types making use of simple optical principles.

The set consists of five, four of which are modifications of the Fresnel's lens. The fifth is the common bull's eye lens. This set will be found exceedingly instructive and a study of the principles involved will be found interesting . . . . . Per Set of Five $2.50

MOUNTED LENSES



Nos. 74–210 to 74–215

Nos. 74–220 to 74–225

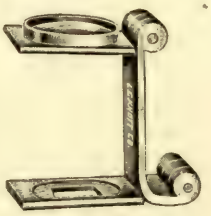
74–210 MOUNTED CONDENSING LENS. This is our No. **74–172** lens mounted on a stand, adjustable to height and plane. The stand is of brass and of a design constructed to facilitate in obtaining all positions desired for the lens in laboratory practice. Brass parts are polished and lacquered; base is finished in black japan.
Complete as illustrated **$5.90**

74–215 MOUNTED DOUBLE CONVEX LENS. This is our No. **74–126** double convex lens, mounted in a universally adjustable stand described under No. **74–210** **5.75**

74–220 MOUNTED HOLLOW PLANO-CONVEX LENS. This is our No. **74–180** water lens, mounted as illustrated **5.25**

74–225 MOUNTED HOLLOW DOUBLE CONVEX LENS. This is our No. **74–182** water lens, mounted as illustrated above **5.25**

No. 74–230



No. 74–235

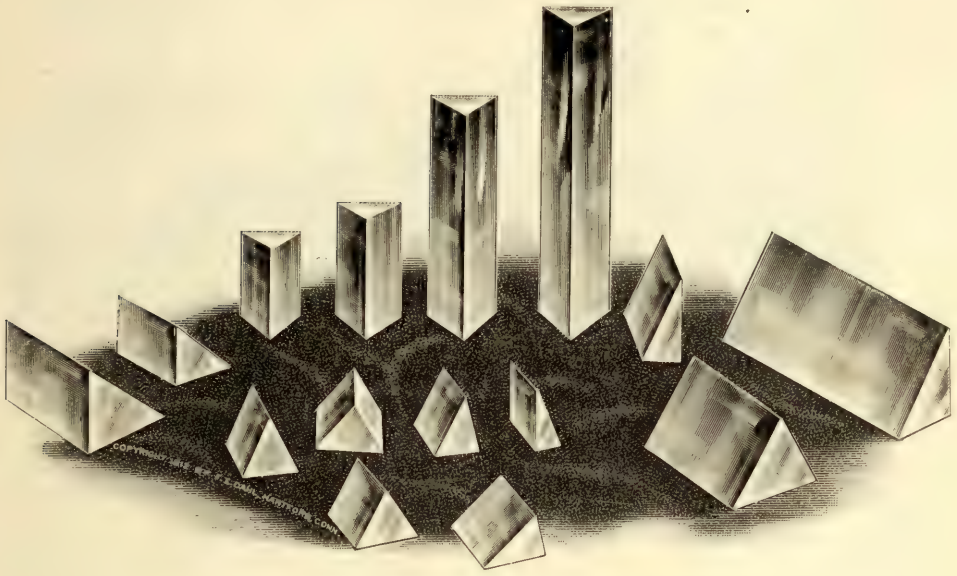
74–230 READING LENS. This is a double convex lens, mounted in a metal frame and provided with handle. Diameter of lens 3 inches **$1.00**

74–235 POCKET MAGNIFIER (LINEN TESTER). This is a small double convex lens, short focus, ½-inch aperture. It is mounted in a brass piece that may be folded into small compass . . . . . **.24**

No. 74–240

71–240 KUEHNE'S EYE MODEL, for the demonstration and study of the optical construction of the eye, its normal and abnormal condition and the necessary corrections.
The apparatus consists of a water-tight rectangular box with various accessories such as the two corneas, one of which is fitted with a cylindrical lens, two eye lenses of different foci, three diaphragms, retina and six glasses to be used in front for correcting errors.
Apparatus complete as above described, including full instructions for use **$28.00**

LABORATORY PRISMS



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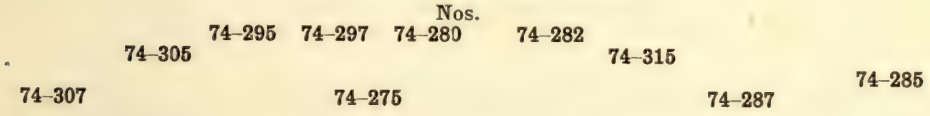


74–275 STUDENTS' ODD ANGLE GLASS PRISMS, for general laboratory uses, particularly for determining the index of refraction.

The tendency of pupils to copy results has led to the demand for prisms with odd angles. The set listed below is one that has found favor in the laboratories of Cornell University and we have no hesitancy in recommending its use in any laboratory. The set consists of six prisms about 1 inch high and 1 inch face, with the following angles: first prism, 55°, 65°, and 60°; second prism, 48°, 69°, and 63°; third prism 54°, 67°, and 59°; fourth prism, 42°, 74°, and 64°; fifth prism, 43°, 74°, and 63°; sixth prism, 23°, 90°, and 67°.

Set of six prisms in neat cardboard box **$5.35**

74–280 EQUILATERAL PRISM, flint glass, square ends, 30-millimeter face, 4 inches long . . . . . **.33**

74–282 EQUILATERAL PRISM, flint glass, square ends, 30-millimeter face, 6 inches long . . . . . **.50**

74–285 EQUILATERAL PRISM, flint glass, square ends, 50-millimeter face, optically true surface, 4 inches long . . . . . Duty Free **14.25**

74–287 EQUILATERAL PRISM, flint glass, square ends, 40-millimeter face, about 2 inches long, surfaces optically true **10.50**

74–295 EQUILATERAL PRISM, crown glass, square ends, 25-millimeter face, 1½ inches long. . . . . **.50**

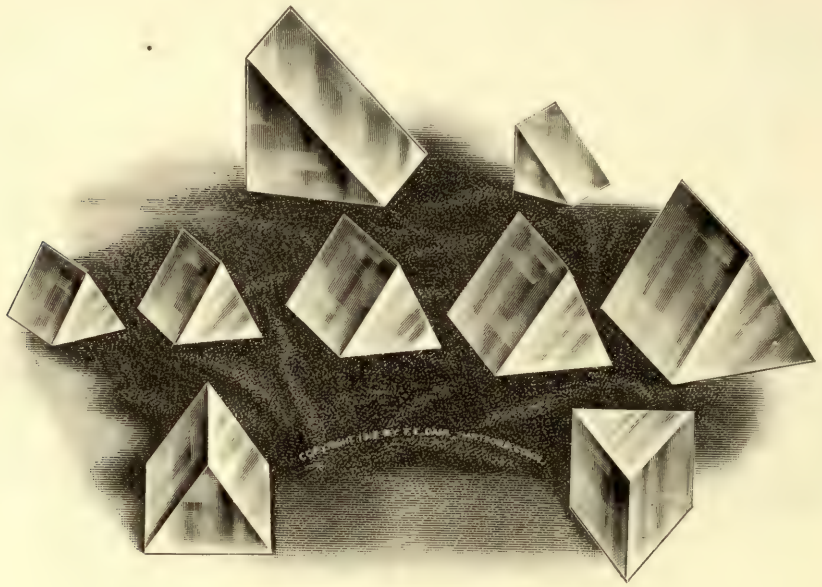
74–297 EQUILATERAL PRISM, crown glass, square ends, 25-millimeter face, 2 inches long . . . . . **.70**

74–305 RIGHT ANGLE PRISM for total reflection, angles of 45 and 90 degrees, sides 25 by 25 millimeters, length 1½ inches . . . . . **.40**

74–307 RIGHT ANGLE PRISM for total reflection, angles of 45 and 90 degrees, sides 38 by 38 millimeters, length 2 inches . . . . . **.50**

74–315 FLINT GLASS PRISM, refracting angle of 20°, sides 41 millimeters, length 1½ inches . . . . . **.50**

SPECTROSCOPIC PRISMS



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Nos. 74–367 **Nos. 74–365**

Nos. 74–350 a-e, to Nos. 74–360 a-e

Nos. 74–390 a-c **Nos. 74–400 a-c**

74–350 **FLINT GLASS EQUILATERAL SPECTRAL PRISMS,** optically true surfaces, square ends.
Refractive Index for D = 1.602; Dispersion C–F = 1° 58′; Minimum for M/D = 55° 20′

	a	b	c	d	e
Side	25	30	35	40	50 millimeters
Each, Duty Free	**$4.75**	**5.25**	**6.25**	**7.40**	**9.75**
Each from Stock	**6.25**				

74–360 **CROWN GLASS EQUILATERAL SPECTRAL PRISMS,** optically true surfaces, square ends.
Refractive Index for D = 1.517; Dispersion C–F = 41′; Minimum for M/D = 50° 24

	a	b	c	d	e
Side	25	30	35	40	50 millimeters
Each, Duty Free	**$4.75**	**5.25**	**6.25**	**7.40**	**9.75**
Each from Stock	**6.25**				

74–365 **CROWN GLASS SPECTRAL PRISMS,** angles of 45 and 90 degrees, cathetus 25 millimeters.
Duty Free **$5.25**

74–367 **CROWN GLASS SPECTRAL PRISMS,** angles of 45 and 90 degrees, cathetus 50 millimeters.
Duty Free **9.40**

74–370 **RUTHERFORD'S COMPOUND ACHROMATIC PRISM,** consisting of a flint glass prism luted between two crown glass prisms.

	a	b	c	d	e
Side	20	30	40	50	60 millimeters
Each, Duty Free	**$9.75**	**14.50**	**23.25**	**38.50**	**49.75**

74–380 **AMICI'S DIRECT VISION PRISM,** consisting of three prisms so arranged as to give direct vision.

	a	b	c	d
Cross-Cut	10	20	30	40 millimeters
Each, Duty Free	**$4.75**	**12.25**	**18.50**	**39.75**

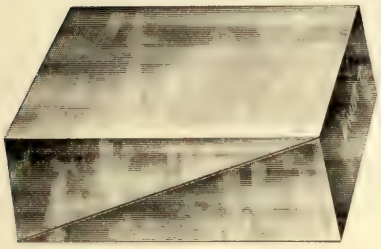
74–390 **EQUILATERAL QUARTZ PRISMS,** with the refracting edge perpendicular to the optical axis.

	a	b	c
Side	25	35	45 millimeters
Each, Duty Free	**$8.50**	**14.25**	**22.00**

74–400 **EQUILATERAL QUARTZ PRISMS,** having the refracting edge parallel to the optical axis.

	a	b	c
Side	25	35	45 millimeters
Each, Duty Free	**$8.50**	**14.25**	**22.00**

MISCELLANEOUS PRISMS



No. 74–410

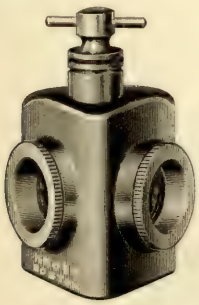
No. 74–425

74–410 **ACHROMATIC PRISMS,** faces polished optically true and carefully fitted.

	a	b	c	
Aperture	25	35	50	millimeters
Each, Duty Free . .	**$5.75**	**7.40**	**9.80**	

74–420 **WEINHOLD'S DEMONSTRATION PRISMS,** for explaining dispersion and achromatism without deviation of the mean ray.
Consists of three prisms, two of crown and one of flint glass, ground and polished optically true.
Set of three, without mounting of any kind . . . . . Duty Free **$9.75**

74–425 **POLYPRISM,** for showing that the angle of deviation increases with the refractive index.
Each prism consists of four glass parts which are unequally refringent, luted to form a prism. Length of side, 35 millimeters . . . . . Duty Free **9.25**



No. 74–430

No. 74–432

Nos. 74–434 to 74–435

74–430 **IMPROVED CAST HOLLOW PRISM.** The design illustrated above pictures our new model hollow prism, indestructibly constructed of cast metal with openings in two sides closed in an ingenious manner by optical plate glass. This prism will be found adequate for most laboratory work, and results are entirely satisfactory.
It is finished with a durable dull black coating **$3.75**

74–432 **OPTICAL GLASS CEMENTED FACE HOLLOW GLASS PRISM,** two faces cemented and polished, the third face blackened, ground glass stopper, height 65 millimeters, face 32 millimeters **4.50**

74–434 **HOLLOW GLASS PRISM,** equiangular, of best ground and polished crystal plate glass, with ground glass stopper, partition cemented in the middle for two liquids. Mounted on wooden foot, 120 millimeters high by 80 millimeters face . . . . . Duty Free **7.50**

74–435 —— same as above, but 100 millimeters by 60 millimeters wide . . . . . Duty Free **6.25**

No. 74–438

74–438 **WEDGE-SHAPED TROUGHS,** a pair of wedge-shaped troughs each 6 inches long by 2 inches wide, refractive angles of 20° . . . . . Duty Free **$5.50**

MOUNTED PRISMS

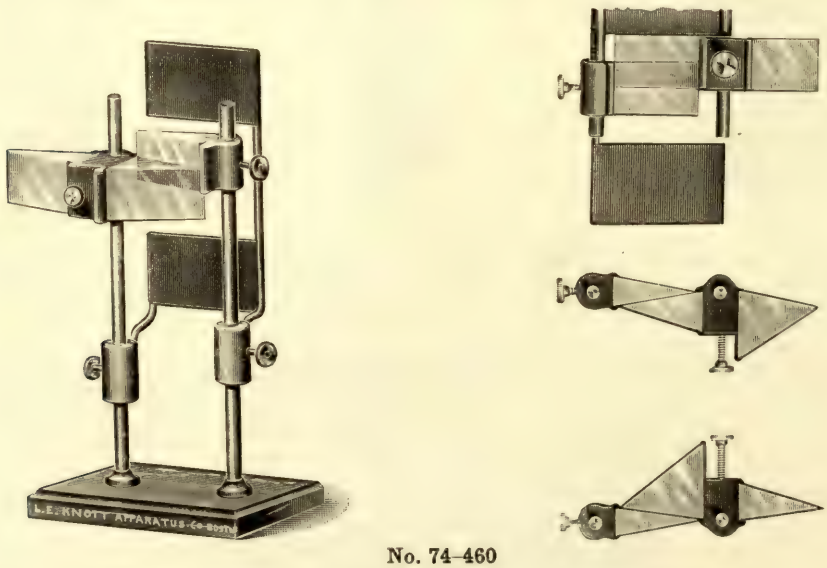
No. 74–450

74–450 **MOUNTED EQUILATERAL PRISM.** This is the same prism as No. **74–280,** mounted on a stand as illustrated. This stand can be raised and lowered to any desired height or inclined to any angle. It is handsomely finished and the base offers a substantial support **$5.75**

74–452 ——, similar to above, but prism 6 inches long. (Same prism as No. **74–282**) **6.90**

74–455 **MOUNTED TOTAL REFLECTION PRISM,** consisting of a right angle prism, flint glass, angles of 45 and 90 degrees, mounted on stand as illustrated in No. **74–450** **6.25**

TOTAL REFLECTION PRISMS OF LARGE DIMENSIONS. See Section **79.**



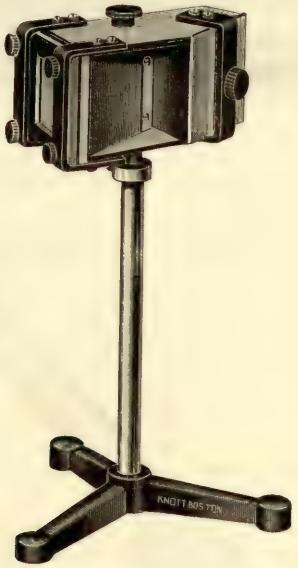
No. 74–460

74–460 **WEINHOLD'S DEMONSTRATION PRISM,** for explaining dispersion and achromatism without deviation of the mean ray.

This apparatus consists of our No. **74–390** set of three prisms conveniently mounted for the greatest utility and ease of adjustment. The lower combination gives an achromatic arrangement while the upper gives direct vision dispersion. For demonstration, best results are secured by arranging the prisms so that the field is divided into three portions, the center of which is due to the combination. (See illustration at right.)

Complete with three prisms, each separately mounted, with supporting stand . . . . . Duty Free **$17.25**

DIRECT VISION AND POLYPRISMS

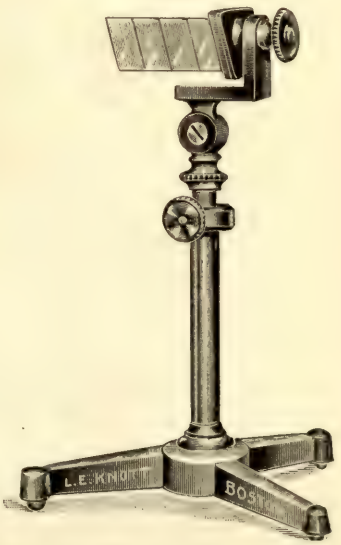


No. 74–470

74–470 **DIRECT VISION PRISM,** after the original specifications of the late Mr. Eaton of Brooklyn, N. Y., for projection of spectra on a screen.
This prism consists of a combination of two prisms, one of dense glass, the other a hollow prism which in use is filled with carbon bisulphide, the angles of each of which are very nicely calculated, giving a direct vision spectrum of large dispersion. At a distance of twenty feet from the screen, with a ¼-size objective, it is possible to secure a clear spectrum band 6 feet long by 2 feet wide.
Mounted on rod telescoping into neat tripod stand **$27.50**

No. 74–480

74–480 **POLYPRISM,** illustrating the phenomena of multiple refraction.
This apparatus consists of a cylindrically shaped wooden frame, in one end of which is mounted a prism, the face of which is cut into a series of very small prisms. The other end is provided with an aperture, so that an object such as a line may be viewed.
Curious and interesting modifications of the shape of an object are noted. The apparatus is small, easily handled, and will be found of considerable qualitative value **$0.22**



No. 74–482

74–482 **MOUNTED POLYPRISM,** for showing that the angle of deviation increases with the refractive index.
The prism is mounted on a universally adjustable stand as illustrated. It is made up of substances which are unequally refringent. If an object such as a line be viewed from the polyprism, its different parts are seen at unequal heights, the highest portion being that seen through the flint glass, — the part of the prism that has the greatest refractive index, and then in order of the decreasing refractive indices. Polyprism mounted on stand as illustrated . . . . . Duty Free **$13.50**

OPTICAL INSTRUMENTS

TELESCOPES SEXTANTS

No. 75–30

75–30 ACHROMATIC TELESCOPE, extra quality, morocco-covered body, polished brass slides, cap for object glass and sliding cover for eye lens. Length closed 5½ inches, three draws to 14 inches long, magnifying power 12 diameters **$2.50**

ASTRONOMICAL TELESCOPES

No. 75–80

Among the high-grade telescopes now presented to the public no instruments have become so widely or so deservedly popular as the line herewith listed. Due to improved methods of manufacture and the consequent diminishing of the manufacturing cost, a high-grade instrument, like an astronomical telescope, has ceased to be the mere instrument of a profession, and the prices have become so reasonable that it is possible for a school or college to number one among its equipment.

The instruments herewith listed are noted for their optical range and capacity. The mechanical features are unexcelled and all accessories are of the same high quality. The policy of the manufacturers has been to make of each telescope an instrument reliable in quality and moderate in price. Each instrument is furnished fully equipped for good work by day or night.

75–50 **PORTABLE ASTRONOMICAL TELESCOPE.** This instrument has been designed light in weight for use on a table or stand. It has the same high optical qualities as have all the models of this manufacturer. Body of telescope, sliding tube for eye-pieces, and tubular support for table tripod, are of polished brass. Feet of tripod are wrought steel, japanned. The instrument has detachable sunglass, brass cap for protection of object glass, and rack and pinion focusing adjustment. Three eye-pieces are furnished: one terrestrial eye-piece, power 45, and two astronomical eye-pieces, powers 50 and 114. Diameter of object lens, 3 inches; length of tube when closed, about 39 inches, — when extended, about 59 inches.

Telescope enclosed with table tripod in neat wooden box . . . . . Duty Free **$47.50**

75–55 ——, same as above, but provided with large hardwood tripod in addition to the table tripod above furnished. Enclosed in neat wooden box . . . . . Duty Free **54.00**

75–60 **ASTRONOMICAL TELESCOPE.** This instrument is somewhat more elaborate than the preceding and has a greater focal length. In addition, the tripod is especially designed for stability and strength and is furnished with a simple but effective cranking adjustment for increasing or decreasing the height of the telescope. It is made of finely finished mahogany. Its construction insures rigidity and affords special steadiness of the telescope.

Each instrument includes a sun-glass, and three eye-pieces: one terrestrial and two astronomical. The power of the terrestrial eye-piece is 54 and the powers of the astronomical eye-pieces are 60 and 120. The size of the object lens is 3 inches; the telescope body with cap is of polished brass; length of tube when closed, about 46 inches, — extended, about 63 inches.

The instrument is furnished in wooden box with handle, lock, and key . . . . . Duty Free **96.00**

75–65 ——, similar to above, except that the object lens is 3¼ inches in diameter and the telescope is somewhat larger in size. The magnifying power of the terrestrial eye-piece is 59. The powers of the astronomical eye-pieces are 65 and 130. Length of tube closed is about 48 inches, — extended, 68 inches.

In neat wooden box with handle, lock and key . . . . . Duty Free **114.00**

75–70 ——, same as above, but provided with a " finder." This telescope is provided with a sun-glass and five eye-pieces: two terrestrial, magnifying 49 and 59 respectively, and three astronomical eye-pieces, magnifying respectively 65, 88 and 146 times.

Enclosed in wooden box . . . . . Duty Free **123.50**

75–75 ——, same as above, except that object lens is 3¾ inches in diameter, and the instrument is furnished with two terrestrial eye-pieces, powers 55 and 66, and four astronomical eye-pieces, powers 74, 99, 147 and 221. Length of tube closed, about 53 inches, — extended, about 73 inches.

Enclosed in wooden box . . . . . Duty Free **178.00**

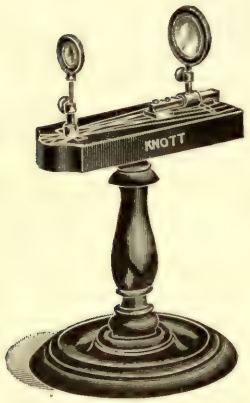
75–80 **ASTRONOMICAL TELESCOPE** (illustrated on preceding page). Uniting all the chief advantages of the types previously listed, this telescope is also provided with still another desirable feature. Each instrument is provided with two slow motions, making it possible for the astronomical observer to control the telescope with greater precision and with the least possible vibration. Tangent screws encased by rods that may be slowly turned by a very slight motion of the hand enable the observer to keep the object in field of view.

The telescope includes " finder," sun-glasses for the astronomical eye-pieces and five eye-pieces: two terrestrial eye-pieces, powers 49 and 59, and three astronomical, powers 65, 88 and 146. The size of the object lens is 3¼ inches. Telescope body, etc. are of polished brass, with brass cap to protect the eye lens. The tripod is especially strong and stable, and is constructed of mahogany, and, in addition to the slow motion adjustments already noted, has a special cranking mechanism for adjustment of the height. Length of tube when closed, about 48 inches, — extended, about 68 inches.

In wooden box with handle, lock and key . . . . . Duty Free **178.00**

75–85 ——, same as above, but larger in size. Object lens 3¾ inches in diameter. Six eye-pieces: two terrestrial eye-pieces, powers 55 and 66, and four astronomical, powers 74, 99, 147 and 221. Length of tube when closed, about 53 inches, — extended, about 73 inches . . . . . Duty Free **254.00**

TELESCOPE MODELS



No. 75–150

No. 75–152

These models consist of lenses mounted in holders placed appropriately for the best definition.

The holders are mounted on a cross-head attached to a neatly finished wood stand. The paths which the rays take are sketched on the flat face of the cross-head. These models will be found instructive and as the magnification and definition are excellent they will be found of great utility.

75–150 **GALILEO'S TELESCOPE MODEL,** comprising two lenses, the object glass, and a diverging or double concave eye-piece. This instrument illustrates the common Opera Glass, giving an erect image . . . . . Duty Free **$4.50**

75–151 **ASTRONOMICAL TELESCOPE MODEL,** consisting of two lenses, one the condensing eye-piece and the other the object glass. In comparison with No. **75–154**, model of the microscope, it will be seen that this astronomical telescope is analogous to the microscope, differing in the respect that, in the microscope the object being seen through the object glass the image formed must be on the principal focus and is, therefore, greatly magnified, so that both the object glass and the eye-piece magnify, while in the astronomical telescope the heavenly body being at a great distance the rays are parallel and the image formed on the principal focus of the object glass is much smaller than the object. There is, therefore, little magnification except that secured by the eye-piece, which usually is of short focal length.

The lines which represent the path of the rays bring this out very clearly in object models. Duty Free **6.40**

75–152 **TERRESTRIAL TELESCOPE MODEL,** consisting of two condensing lenses placed between the object glass and the eye-piece. It will be noted that this telescope differs from the astronomical telescope in that it produces images in their right positions . . . . . Duty Free **7.15**

75–153 **TELESCOPE MODELS,** as listed above, showing the construction of the principal telescopes, set of three . . . . . Duty Free **18.00**

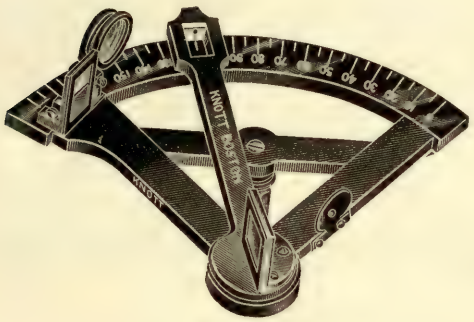
75–154 **MICROSCOPE MODEL,** consisting of two lenses, one the objective, the other the eye-piece. Duty Free **4.50**

75–155 **DEMONSTRATION MICROSCOPE,** after Millikan & Gale's "A Laboratory Course in Physics," Experiment 45, for determining the magnifying power of a microscope.

The apparatus consists of a brass tube, on either end of which are placed strips with apertures. Over one end is fastened a linen tester, No. **74–235**. Apparatus complete with two linen testers . . . . . **.80**

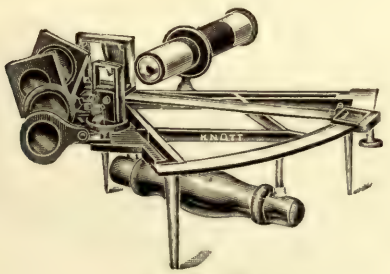
75–156 **TUBE** only, without linen testers . . . . . **.22**

REFLECTING SEXTANTS



No. 75–165

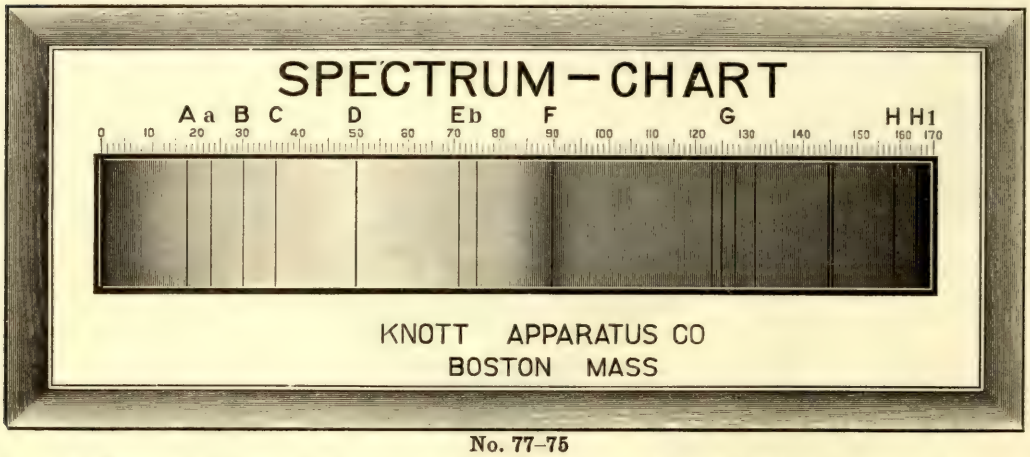
75–165 **SEXTANT,** for measuring the angle between any two distant objects. This is a universal, durably constructed wooden model reading to one degree of arc. It must not be confused with a number of wooden models at present on the market, as this is an accurately working instrument provided with most of the adjustments of an expensive metal Engineer's and Mariner's Sextant. Duty Free **$12.00**



No. 75–170

75–170 **REFLECTING SEXTANT,** for measuring the angle between any two distant points.
This is an accurately constructed, brass sextant capable of exact determinations, reading by vernier to 5 minutes of arc. It is provided with an astronomical telescope of 12 millimeters' aperture and with blend glasses as illustrated . . . . . Duty Free **$24.50**

ANALYSIS, INTERFERENCE AND DIFFRACTION OF LIGHT



No. 77–75

77–75 **SUN SPECTRUM CHART,** hand painted on linen, spectrum band about 48 inches long by 7 inches wide. Frauenhofer lines indicated and colors carefully matched and work well executed. Mounted in frame to occupy wall space of about 5 × 2 feet. This chart will make a valuable addition to any laboratory, either in quantitative or qualitative study of the sun's spectrum . . . . . Duty Free **$36.50**

77–80 **SPECTRUM CHART,** after Kirchhoff and Bunsen.
This chart is of ample size for framing, if desired, showing beautifully the spectrum of the Sun, K, Rb, Cs, Fl, Na, Li, Ca, Sr and Ba **3.90**

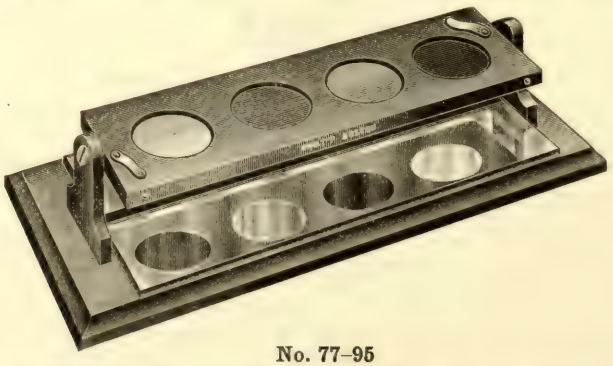
77–82 **SPECTRUM CHART,** after Kirchhoff and Bunsen, showing the following spectra: Sn, C, Bo, Mn, Cu, Co, Ni and Fe **3.90**

77–85 **SPECTRUM CHART,** illustrating the Solar Spectrum.
This Chart consists of a strip of paper on which the spectrum is beautifully lithographed. It is about 80 centimeters long and mounted on heavy cardboard. The various Frauenhofer lines are indicated **1.50**

21–210 **COLOR DISCS,** for quantitative work in color mixing and color analysis.
These discs are of heavy cardboard, 12 inches in diameter, with hole for attaching to spindle of rotator. Each disc is slit that two or more colored discs may be combined, giving a disc of several colors 12 inches in diameter.
Set of seven discs of primary colors, one each of black and white, and a percentage circular protractor for quantitative work. (For illustration, see Section **21**) **2.00**

21–220 **COMBINATION NEWTON'S COLOR DISCS,** for showing white light when fixed portions of primary colors are rapidly rotated. (For description and illustration, see Section **21**) **3.90**

77–90 **COLORED GLASS PLATES,** for analysis and study of light.
These plates are selected colored plates of the best "pot glass" colors. They are furnished 10 centimeters square in the following colors: red, orange, yellow, green, blue, indigo and violet.
Per set of seven colors **1.50**



No. 77–95

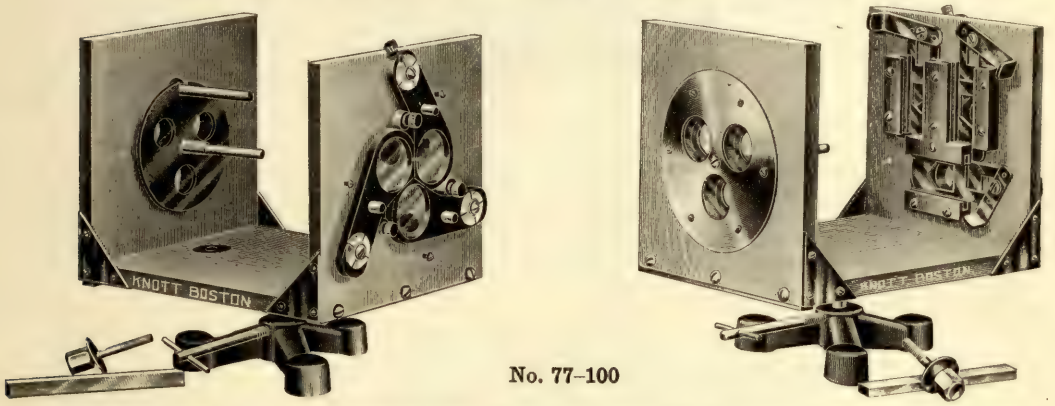
77–95 **COLORS IN REFLECTED AND TRANSMITTED LIGHT.** Not only metals but also certain pigments show in reflected light metallic changeable colors which are in striking contrast to the colors resulting from light transmitted through thin discs of the same substances. By means of our apparatus above illustrated we allow the simultaneous observation of these contrasted colors.
Glass discs are set into four circular holes of a support. These are covered with different metallic pigments and substances which in reflected light show certain colors but in light transmitted by a mirror underneath show distinctly different. The contrast between these two sets of colors thus seen at a glance is extremely striking.
The apparatus is neatly made and results are positive **$4.25**

THE VON NARDROFF COLOR APPARATUS

DESIGNED FOR THE STUDY OF COLOR PHENOMENA

An Attachment for the Projection Lantern or Porte Lumiere

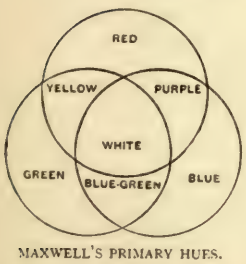
Made under the personal supervision of Mr. F. W. Huntington



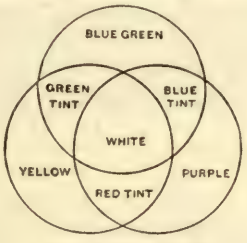
No. 77–100

77–100 VON NARDROFF COLOR APPARATUS. This apparatus was designed by Dr. von Nardroff, Principal of the Stuyvesant High School, New York City, for the convenient and satisfactory study of color phenomena where only one Projection Lantern is available. Our method of mounting is such that it is equally well adapted for use with the Porte Lumiere.

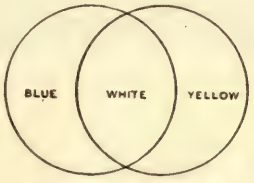
Briefly, it is an attachment that converts an ordinary Projection Lantern into a triple lantern in which each of the three beams of light is independent both as to intensity and direction. The general form and design will be clearly indicated by the cuts above, showing two positions.



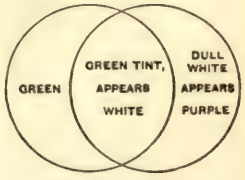
MAXWELL'S PRIMARY HUES.
Fig. 1.



FALSE PRIMARY HUES
Fig. 2



COMPLEMENTARY HUES.
Fig. 3.



CONTRAST EFFECTS.
Fig. 4.

EXPERIMENTS

A STUDY OF PRIMARIES AND SECONDARIES (see Fig. 1). The red, green, and blue glasses provided with the apparatus are placed in the glass holders shown in the diagram. By a movement of the lens arm these circles of red, green, and blue may be overlapped either in whole or in part as desired and, by means of the diaphragms, the intensity of strength of each color readily regulated. The effect of mixing the primaries in any desired portion, in pairs or in triples, is readily seen.

FALSE PRIMARIES (see Fig. 2). In this illustration the glasses selected should be the purple, yellow, and blue-green, and by proper manipulation of the diaphragms all possible hues, as well as white, may be obtained.

COMPLEMENTARY HUES (see Fig. 3) are easily illustrated by carefully choosing the pairs of colored glasses to obtain the desired results.

"THE GREEN QUESTION" is solved by super-imposing the yellow and blue glasses in the single slide holder of the apparatus and again inserting the same glasses in separate slide holders, adding the beams by over-lapping on the screen, noting that a pure white light is obtained.

CONTRASTING EFFECTS (see Fig. 4) are strikingly illustrated when a saturated color, such as green, is projected and the white disc arranged to partially over-lap turned on; the over-lap, which is really a tint, appearing nearly white, while the remaining white appears strongly colored of the complementary hue. If the order of projection is reversed, the sudden appearance of the white is very impressive.

A STUDY OF TINTS is easily made by adding to the white beam a colored beam adjusted for intensity.

OTHER EXPERIMENTS. Many additional experiments will suggest themselves to the user after he has become familiar with the apparatus and commences to learn some of its possibilities; such, for instance, as three equally bright beams being made to partially over-lap. The remaining portions of the beams will present intensities as the ratio of 1: 2: 3. Again, projecting on the screen a compound white, holding an opaque body in the path of the ray, a very remarkable shadow effect will be produced.

Full directions for use are furnished with each instrument.

Price mounted as illustrated **$32.00**

SPECTROSCOPES

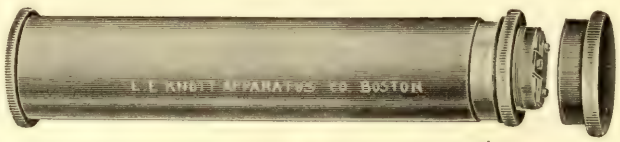
DIRECT VISION— DIFFRACTION SPECTROSCOPES

Nos. 77–125 to 77–135

77–125 **DIRECT VISION POCKET SPECTROSCOPE,** for use in experiments in Spectrum Analysis.
This instrument consists of a combination of three prisms giving a considerable dispersion. It will show many of the Frauenhofer lines, the bright lines of the metals and gases and the absorption bands in colored gases, crystals, or liquids. It is provided with an adjustable slit operated by a small micrometer screw. This spectroscope has an achromatic lens and is of excellent quality throughout.
Enclosed in velvet-lined case **$9.00**

77–126 ——, same as above, but fitted with a comparison prism which will show two spectra in the field of view at the same time, so that they may be conveniently compared.
Enclosed in velvet-lined case . . . . . Duty Free **14.50**

77–135 **"MINIMUM" POCKET DIFFRACTION SPECTROSCOPE,** useful as a pocket instrument for all classes of color work and excellent in chemical industries.
This spectroscope will give a dispersion of about 20 degrees or about double that of an ordinary direct vision prism spectroscope. It will readily show the more prominent Frauenhofer lines, and will distinctly show the rainband line **10.50**



No. 77–137

77–137 **REGULAR POCKET SPECTROSCOPE,** similar to No. **77–135,** but built on larger lines, giving a dispersion of about 30 degrees and will show hundreds of lines in the Solar-Spectrum, the D lines being well separated and the B group admirably shown.
The instrument is provided with an adjustable platinoid slit and a sliding focusing adjustment.
Duty Free **$19.25**

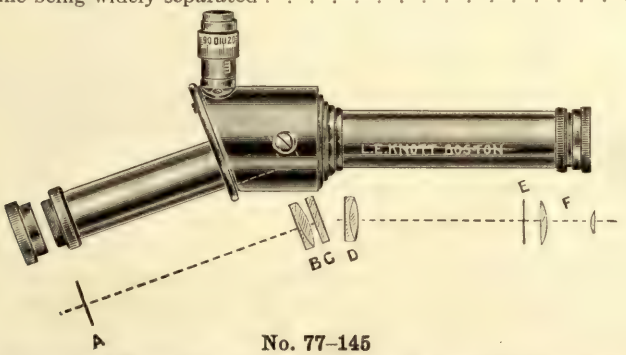
No. 77–139

77–139 **DIRECT READING DIFFRACTION SPECTROSCOPE,** for Spectrum Analysis.
This instrument has the same perfections and qualities as the one above, but has a most important addition. Upon looking through the instrument, the spectrum will be seen, but above the top there will also be seen an illuminated arrow point. A graduated milled head moves this point along the spectrum and any lines can be registered directly. By means of the graduations of this revolving drum, the positions of numbers of lines can be rapidly recorded. As the pointer is illuminated by the actual source of light that gives rise to the spectrum, both spectrum and pointer will have equal intensity of illumination. The readings, therefore, will correspond to the wave lengths of light. The whole spectrum is divided into 500 divisions and a glance at the sun, reading two or three important and easily recognized lines, will give at once the ratio that the scale bears to the actual wave length . . . . . Duty Free **$27.50**

Nos. 77–142 to 77–143

77–142 **MOUNTED DIRECT READING DIFFRACTION SPECTROSCOPE,** for Spectrum Analysis.
To meet the demand for an instrument mounted for accurate work, the previous spectroscope has been built on larger lines and mounted on a heavy tripod stand with universal adjustments and clamp. An improvement has been made in the screw adjustment over that of No. **77–139**, obviating the liability of damage to the delicate projecting screw, by means of a smoothly rotating collar. The stand is further supplied with a carrier as illustrated for holding material over the flame.
Complete as illustrated, without burner . . . . . Duty Free **$42.00**

77–143 ——, similar to the above, but built on a larger scale, the spectroscope giving a dispersion of 60 degrees,the D line being widely separated . . . . . Duty Free **48.50**



No. 77–145

77–145 **DIRECT READING WAVE LENGTH SPECTROSCOPE,** for Spectrum Analysis.
The Spectroscope is so constructed with a Diffraction Grating that the positions of the lines in the Spectrum are read direct on a Revolving Drum in Angstrom units. This instrument is inexpensive but gives remarkably accurate results. With the ordinary eye-piece the dispersion is about 30 degrees and the whole of the spectrum is in the field of view at once. The instrument consists of a Collimator with an adjustable slit at one end and an object glass at the other, with a 14,500 line Diffraction Grating fitted into the same tube. Attached to this tube is a telescope with an object glass at one end and an eye-piece with cross wires at the other. The centers on which this telescope is hinged are on a level with the grating and the telescope is moved by a Micrometer screw divided into 100 parts. This screw moves the telescope on a true sine motion so that the positions of the lines in the spectrum as they travel across the cross wires are read in wave length measurements, each division being equal to 10 Angstrom units. An index gives the number of turns of the screw.
By the addition of a high power eye-piece the dispersion may be increased to 90 degrees, but the field is cut down thereby to about one-third of the spectrum.
Direct Reading Wave Length Spectroscope, with low power eye-piece and mounted on adjustable table Stand . . . . . Duty Free **$44.50**

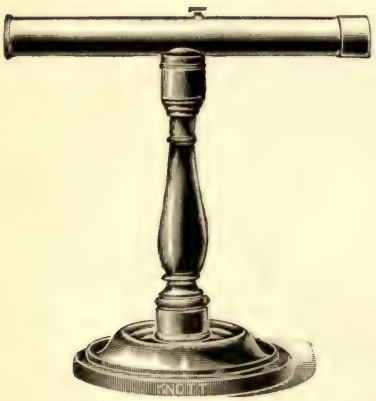
77–146 **HIGH POWER EYE–PIECE,** for use with above to increase the angle of dispersion . Duty Free **4.75**

SPECTRAL APPARATUS

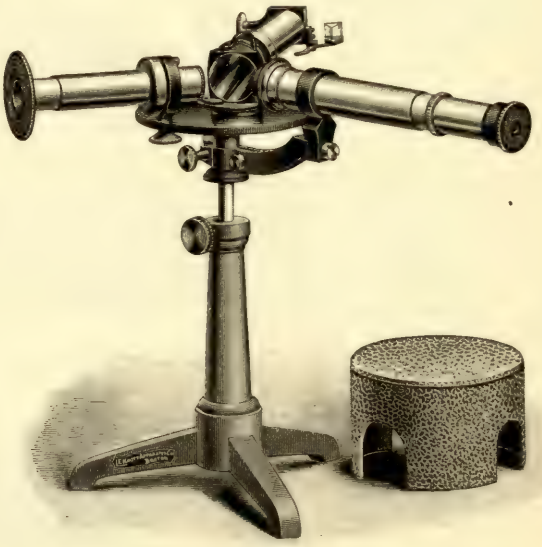
No. 77–160

77–160 SIMPLE DEMONSTRATION SPECTRAL APPARATUS AND GONIOMETER. The illustration above pictures a simple spectral apparatus capable of a fair degree of accuracy. Designed for demonstration purposes, yet its utility as an elementary spectroscope and goniometer has given it an important place as a student's instrument. As may be noted, all parts are open to view, — the lenses in a neat mounting may be focused by sliding along the rods. The prism table is adjustable and graduated. Mounting for prism is movable. Holder for Slit is fixed, but slit is adjustable.

Complete as illustrated with Candle Holder, Slit, Lenses, and Lens Holders, but without prism . . **$19.25**



No. 77–162



No. 77–170

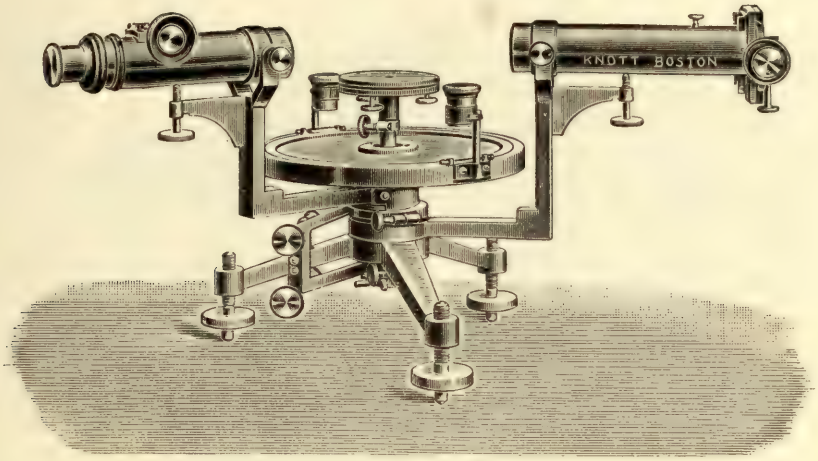
77–162 STUDENT'S SPECTROSCOPE. Many teachers have felt the need of an inexpensive instrument capable of demonstrating to students in a convenient manner and without loss of time the methods of spectrum analysis.

The spectroscope above illustrated is provided with a set of prisms of high dispersion and yields a wide spectrum, showing a large number of Frauenhofer lines. The adjustment of focal length is secured by means of a small handle sliding along the tube. The fixed slit at one end is covered by a glass plate so as to be completely protected from dust. The spectrum in consequence will be free from cross-lines. The instrument is mounted on a neat wooden stand and is provided with holder for test tubes . . . . . Duty Free **$12.75**

77–170 ADVANCED SPECTROSCOPE. This instrument is especially designed for high school and elementary college work. It is furnished completely equipped with all essential parts.

All mechanical details are well constructed and nicely fitted; all optical parts are of the best. The telescope is adjustable, has an aperture of about 20 millimeters and a focal length of about 160 millimeters. The collimator is provided with a comparison prism and is of the same dimensions as the telescope. A separate tube contains the scale. The instrument is mounted adjustably in a neatly finished tripod stand. It is furnished with a 60-degree flint glass prism and provided with a cover for same . . . . . Duty Free **29.80**

SPECTROMETER



No. 77–175

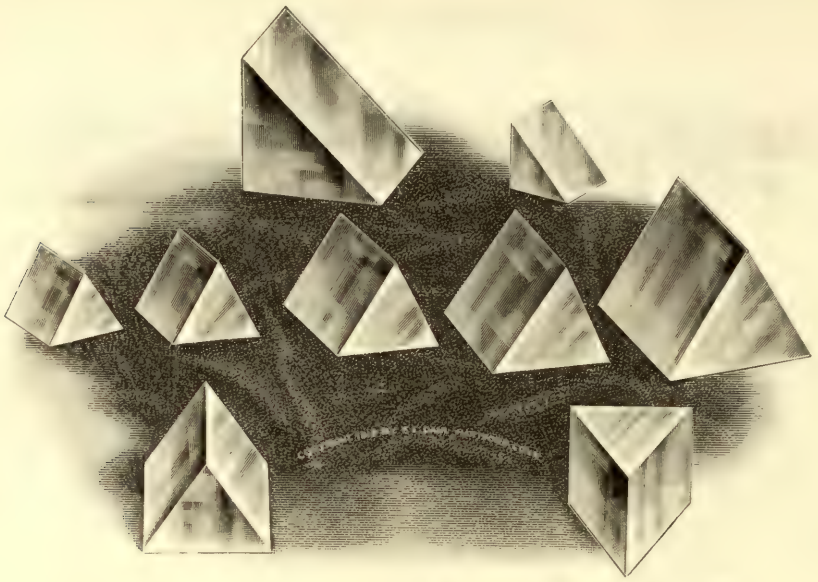
77–175 UNIVERSALLY ADJUSTABLE SPECTROMETER, after V. v. Lang.

The adaptability of this instrument to most spectrometric work has made it one of the most popular spectrometers in use. Constructed by one of the most prominent European manufacturers, it has received every attention in structure. Mechanical parts are accurately constructed and carefully fitted; optical parts calculated to a nicety for the work for which the instrument is intended. The circle is 120 millimeters in diameter with graduations on silver to ½ degree. To facilitate in the reading, the instrument is provided with two verniers with magnifiers which facilitate readings to 60 seconds of arc. The telescope has an aperture of 20 millimeters, is provided with rack and pinion adjustment and may be rotated about the vertical axis. The collimator has same diameter as the telescope and is provided with a slit with micrometer screw adjustment, the extent of opening being indicated on the graduated drum. The prism table is adjustable in height and may be leveled by three small thumb screws noted in the illustration. The instrument is mounted on a neatly finished tripod base provided with leveling screws. All necessary adjustments for telescope tube and collimator and locking device for the latter are provided. This instrument will give universal satisfaction . . . . . Duty Free **$66.00**

WAVE LENGTH OF FRAUENHOFER LINES IN MICRONS (μ) OR THOUSANDTHS MILLIMETERS.

0.1 Micron = 1,000 Angström Units.

Frauenhofer Line	Source	Wave Length in μ	Frauenhofer Line	Source	Wave Length in μ	Frauenhofer Line	Source	Wave Length in μ
	Potassium	.7699	D_2	Sodium	.5890		Calcium	.4878
	Potassium	.7665	D_3	Helium	.5876	F	Hydrogen	.4861
A	Sun	.7604		Mercury	.5790		Strontium	.4607
a	Sun	.7185		Mercury	.5769		Barium	.4554
B	Oxygen	.6870		Mercury	.5461		Mercury	.4358
	Lithium	.6708		Cadmium	.5379	f	Hydrogen	.4340
C	Hydrogen	.6563		Cadmium	.5338	G′	Iron	.4326
	Strontium	.6550	E	Iron, calcium	.5270	G	Iron, calcium	.4308
	Calcium	.6499		Iron	.5270		Calcium	.4227
	Cadmium	.6438	b_1	Magnesium	.5184	h	Hydrogen	.4102
	Strontium	.6408	b_2	Magnesium	.5173		Mercury	.4078
a	Oxygen	.6278	b_3	Iron	.5169		Mercury	.4047
	Mercury	.6152	b_4	Magnesium, iron	.5168		Potassium iron	.4046
	Lithium	.6104		Cadmium	.5086	H	Hydrogen, calcium	.3968
D_1	Sodium	.5896		Barium	.4934			



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No. 74–367 **No. 74–365**

Nos. 74–350 a-e to **Nos. 74–360 a-e**

Nos. 74–390 a-e **Nos. 74–400 a-e**

74–350 **FLINT GLASS EQUILATERAL SPECTRAL PRISMS,** optically true surfaces, square ends.
Refractive Index for D = 1.602. Dispersion C–F = 1° 58′. Minimum for M/D = 55° 20′

	a	b	c	d	e
Side	25	30	35	40	50 millimeters
Each, Duty Free	**$4.75**	**5.25**	**6.25**	**7.40**	**9.75**
Each from Stock	**6.25**				

74–360 **CROWN GLASS EQUILATERAL SPECTRAL PRISMS,** optically true surfaces, square ends.
Refractive index for D = 1.517; Dispersion C–F = 41′. Minimum for M/D = 50° 24′

	a	b	c	d	e
Side	25	30	35	40	50 millimeters
Each, Duty Free	**$4.75**	**5.25**	**6.25**	**7.40**	**9.75**
Each from Stock	**6.25**				

74–365 **CROWN GLASS SPECTRAL PRISM,** angles of 45 and 90 degrees, cathetus 25 millimeters. Duty Free **$5.25**

74–367 **CROWN GLASS SPECTRAL PRISM,** angles of 45 and 90 degrees, cathetus 50 millimeters. Duty Free **9.40**

74–370 **RUTHERFORD'S COMPOUND PRISMS,** consisting of a flint glass prism luted between two crown glass prisms.

	a	b	c	d	e
Side	20	30	40	50	60 millimeters
Each, Duty Free	**$9.75**	**14.50**	**23.25**	**38.50**	**49.75**

SPECTRUM TUBES

Nos. 77–225 to 77–236

No. 77–245

77–225 **GEISSLER SPECTRUM TUBE,** filled with carbon dioxide **$1.65**

77–226 ——, filled with hydrogen gas **1.65**

77–227 ——, filled with nitrogen gas **1.65**

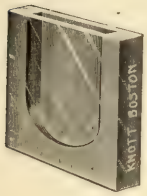
77–228 ——, filled with oxygen gas **1.65**

77–235 **GEISSLER SPECTRUM TUBE,** most carefully constructed, evacuated, and filled with pure argon gas **7.25**

77–236 ——, same as above, but filled with pure helium **7.25**

77–245 **GEISSLER SPECTRUM TUBE,** for evacuating and filling with whatever gas desired. Fitted with two carefully ground glass cocks **1.65**

ABSORPTION TROUGHS



No. 77–265

No. 77–267

No. 77–270

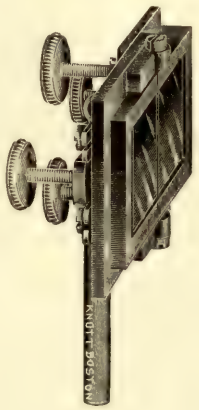
77–265 **ABSORPTION TROUGH, U-SHAPED,** for use as an absorption vessel, light filter or for projection of living matter in liquids.
This trough is durably constructed and the cementing is guaranteed not to leak, being baked in special furnaces at 1000° Fahrenheit. Size 50 millimeters high, 20 millimeters wide, and 4 millimeters deep **$1.65**

77–267 **ABSORPTION TROUGH,** square shaped, with round bore, the same careful construction as above. Inside measurement 20 × 4 millimeters **1.45**

77–270 **DOUBLE ABSORPTION TROUGH,** for comparing two liquids simultaneously, same careful construction as above. Inside measurement of each partition, 40 × 25 × 10 millimeters **6.25**

No. 74–438

74–438 **WEDGE-SHAPED TROUGHS,** a pair of prism-shaped troughs, each 6 inches long by 2 inches high. Refractive angles of 20 degrees . . . . . Duty Free **$5.50**



No. 77–300

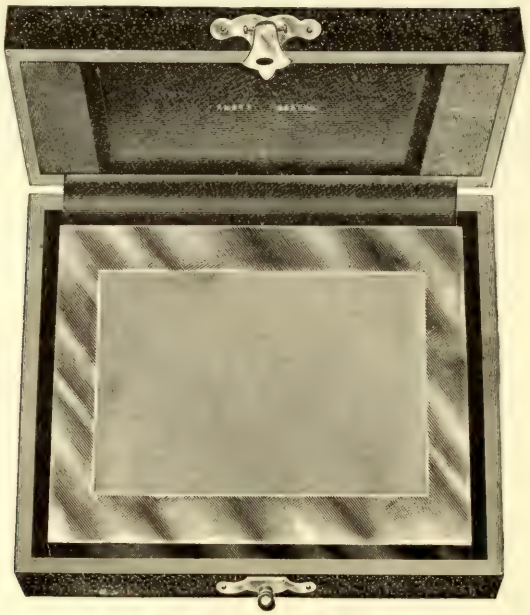
77–300 **ADJUSTABLY MOUNTED FRESNEL'S INTERFERENCE MIRRORS,** for illustrating interference of light by reflection.
The apparatus consists of two optically plane black glass mirrors whose polished surfaces extend right up to the line of intersection of the two faces. These mirrors are provided with **Micrometer Screw Adjustments,** so that the angle between them nay be varied within short limits. For normal use, these mirrors should be at nearly 180 degrees of angle in order to get proper interference. By means of the micrometer screw attachment, however, the complete system of fringes can be caused to pass in succession over any desired part of the screen. The mirror frame is attached to a rod for use with our No. **5–810** Right Angle Clamp for use on an Optical Bench
Duty Free **$14.75**

77–305 **MOUNTED FRESNEL'S BI-PRISM,** for showing interference of light by transmission . Duty Free **8.25**

DIFFRACTION GRATINGS

77–315 PRISM GRATINGS, for spectroscopic and lantern work. Prism Gratings have been designed for obtaining direct vision spectra of great dispersion, while their brilliancy is far greater than plate gratings. They are made of varying angles and sizes to suit requirements and are equal in many cases to 4 to 6 flint prisms, the amount of dispersion being affected by the angle at which the prism is tilted. The surfaces of **a**, **b**, and **c** are accurate to 1/500,000 and of **d** and **e** to 1/50,000 of an inch.

	a	b	c	d	e
Size of Face	61 × 48	38 × 30	28 × 19	64 × 38	28 × 19 millimeters
Each, Duty Free . .	**$34.50**	**21.75**	**16.80**	**19.25**	**9.00**



Nos. 77–320 to 77–325

77–320 TRANSMISSION DIFFRACTION GRATING. These gratings are moulded replicas of Rowland's celebrated metallic gratings of 14,438 lines to the inch. They are mounted on parallel plate glass and are suitable for work of the highest class, both visual and photographic as well as for projection purposes, and give a brilliant and pure normal spectra. Wave length measurements may be safely taken, as each grating has the number of lines per inch marked on it. Size, 28 × 19 millimeters . . . . . Duty Free **$6.80**

77–322 ——, same quality as above, but 54 × 35 millimeters . . . . . Duty Free **9.25**

77–325 TRANSMISSION DIFFRACTION GRATING, same size as No. **77–322**, but on optically worked glass, giving a very brilliant spectrum . . . . . Duty Free **11.40**

No. 77–350

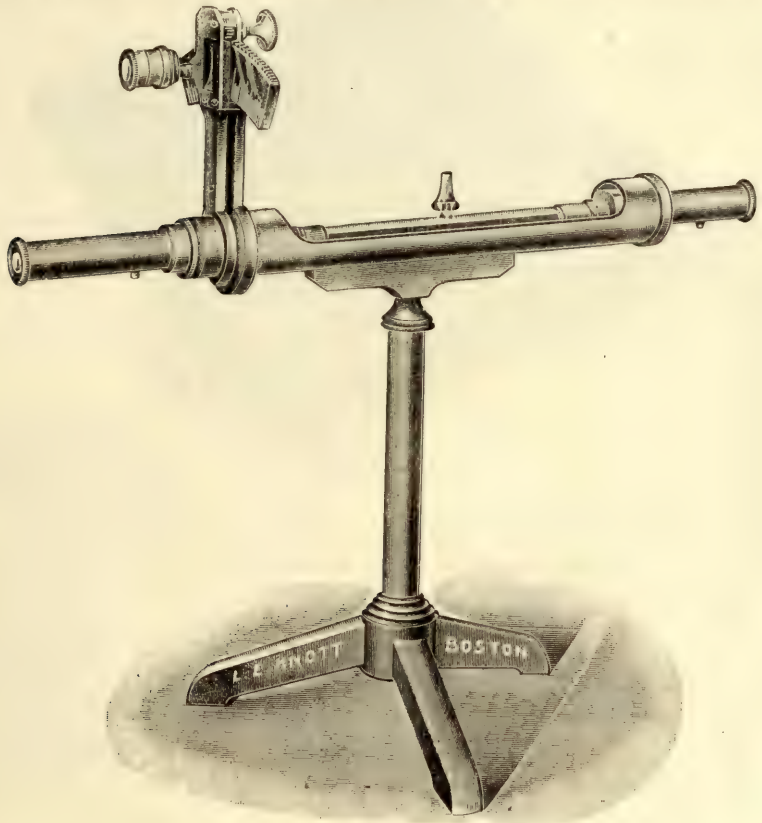
77–350 NEWTON'S RINGS, for illustrating colors of thin plates, demonstrating interference of light, etc. This apparatus consists of two brass rings between which are locked two glasses, one plane and the other convex, of very long focus. The method of locking the two rings is such that by means of the screws, the pressure may be regulated. Diameter of glasses, 1½ inches.

If the two surfaces are exposed to ordinary light in front of the window, so as to reflect light, there is seen at the point of contact a black spot surrounded by 6 or 7 colored rings, the tints of which become gradually less strong. If the glasses are viewed by transmitted light, the center of the rings is white and each of the colors is exactly complementary of that of the rings by reflection. If exposed to light from a monochromatic flame, an interesting study of the colored rings presents itself **$1.50**

77–352 NEWTON'S RINGS, similar to above but of larger size. Diameter, 16 centimeters . . Duty Free **13.50**

POLARIZATION OF LIGHT

NEW PENUMBRA POLARIMETER OR SACCHARIMETER



Nos. 78–20 to 78–24

The model above illustrated has been constructed principally for technical uses. It is intended to be a piece of apparatus intermediate between the Mitscherlich-Laurent and the Lippich Polarimeter. It possesses a graduated scale of the same radius as the Lippich, with the difference that the graduation is not continuous, but forms only a segment. This is, however, fully sufficient for about all of the experiments that would naturally be made. In consequence of the very large arc used, the intervals are decidedly larger, in spite of the fact that the sub-divisions are as small as in the case of the large Laurent Polarimeter. This allows a much more accurate and quicker reading of the measurements, which is particularly important in those cases where very many experiments in polarization are to be made in succession.

A second graduated scale with which this model also is provided makes it possible to use the apparatus also as a simple Saccharimeter.

The apparatus is provided with two graduated scales, therefore, one to one-half degrees, the Vernier of which reads to .05°; and with the second scale graduated according to the Ventzke system, which allows immediate reading of sugar-cane percentages. Both scales are read by means of a reading glass, and the setting is done by means of a tangent screw.

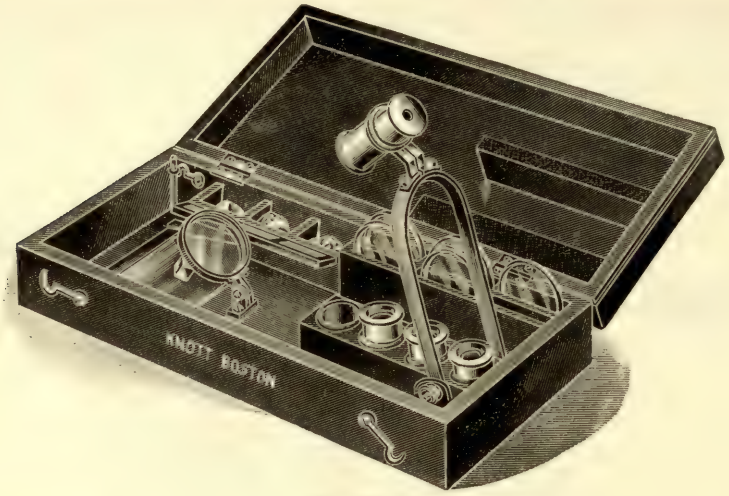
The model is furnished either with a Laurent Polarizer, a Jellett-Cornu (for white light) or with the Lippich Polarizer (for light from any source). The apparatus is constructed to take tubes of any size up to 200 millimeters in length.

78–20 **PENUMBRA POLARIMETER or SACCHARIMETER,** with Laurent penumbra polarizer, but without tube and without lamp . . . . . Duty Free **$44.50**
78–22 ——, with Jellett-Cornu polarizer (for white light), without tube and without lamp . Duty Free **48.75**
78–24 ——, with Lippich penumbra polarizer, without tube and without lamp . . . . . Duty Free **53.00**

ACCESSORIES

78–30 **POLARISCOPE TUBES,** of 100 and 200 millimeter length, and a cell with glass ends for holding liquids. Per set of two . . . . . Duty Free **$7.25**
78–32 ——, of similar construction to the above, but of 94.7 and 189.4 millimeter length. With both of these cells the arc graduation gives the direct percentage of sugar in urine. Per set of two . . Duty Free **8.40**
78–35 **SODIUM LIGHT BURNER** . . . . . Duty Free **6.50**
78–37 **CARRYING CASE.** This case is especially designed for any of the above listed polarimeters, with apartments for the tubes and lamp, and with all necessary blocks for holding the instrument in place . . . . . Duty Free **12.25**

POLARIZATION STUDY APPARATUS



No. 78–40

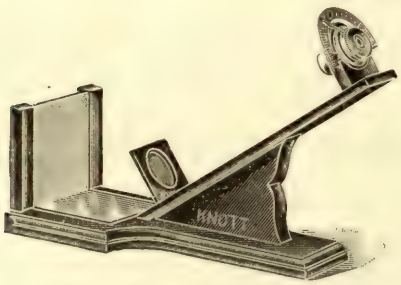
78–40 STUDENTS' POLARIZATION STUDY OUTFIT, for study of effects of polarized light.

There is perhaps no branch of Optics so neglected and yet in which results are so important as that of Polarized Light. The neglect is due in a large measure to the elaborate and costly apparatus designed for this branch. To encourage the study we have secured from our European correspondents the design above illustrated.

With this comprehensive outfit contained in a polished wooden box, each part appropriately mounted and a compartment for each, very beautiful results may be obtained. The Polarizing Black Mirror is mounted at one end, the holder for the Analyzer at the other, a Holder for the different crystals between. The Analyzer consists of a Nicol's Prism mounted in a brass tube. Four other brass tubes each with different crystals are furnished for use in the mounting with the Analyzer. Various Gypsum Figures and Specimens are furnished for study under polarized light.

We cannot too strongly urge the use of this simplified Study Outfit. All parts are carefully made and selections of crystals and specimens are those best adapted to study.

Complete as illustrated . . . . . Duty Free **$26.50**



No. 78–45

No. 78–75

78–45 PICKERING POLARISCOPE, for study of simple objects under polarized light.

This is a simple form of polariscope in which the polarizing mirror covers the stage. The Analyzer is a Nicol's prism 6-millimeter aperture mounted in brass tube. It is provided with pointer and graduated arc. An improved holder is provided for specimens to be studied **$8.00**

ICELAND SPAR. Iceland Spar is a crystallized mineral which produces two refracted beams of light from one incident ray.

Iceland Spar comes in many forms, all of which may be reduced by cleavage to the rhombohedron. This mineral comes in many grades of purity and clarity, although the double refraction can be shown by the quality readily obtained, and as generally listed. We recommend our No. **78–75**.

78–75 ICELAND SPAR, best quality, recommended for its remarkable purity and clarity **$1.50**

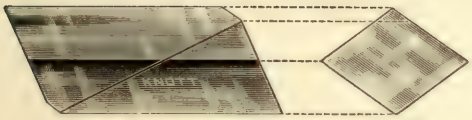
78–76 ICELAND SPAR, large size, medium quality . . . . . **.70**

78–77 ICELAND SPAR, ordinary quality . . . . . **.55**

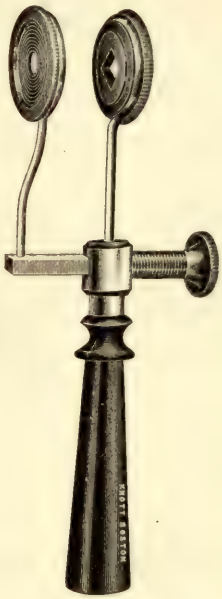
POLARIZING MIRRORS TOURMALINE NICOL'S PRISMS

78–80 POLARIZING MIRRORS, of clear black glass, for polarizing by reflection.
These are the highest quality mirrors set in mahogany frames, size 10 × 20 centimeters . . . . . Duty Free **$3.50**

No. 78–85



Nos. 78–95 to 78–100



No. 78–87

TOURMALINE TONGS. Tourmaline is a uni-axial negative crystal in the form of a regular hexagonal prism from which only the " extraordinary " ray emerges, while the " ordinary " is rapidly absorbed. It can, therefore, be used in producing a polarizing light. The optical axis of tourmaline coincides with the prism and for optical purposes the plate is cut from it parallel to the axis.

In tourmaline tongs used for illustrating and analyzing polarized light, two tourmaline crystals are mounted in discs which are held as illustrated. These discs are each free to move. If the prisms are placed so that their axes are parallel, light emerges as the prisms are turned so that their axes are at an angle. In use, the crystal to be studied under polarized light is placed between the two crystals.

78–85 TOURMALINE TONGS, simple form, medium size tourmaline prisms, capable of ordinary work . **$2.65**

78–87 PARALLELLY ADJUSTABLE TOURMALINE TONGS, superior quality tourmaline plates with improved mounting which allows of wide separation of the plates; also convenient method of turning the tourmaline holders . . . . . Duty Free **11.40**

NICOL'S PRISMS

The ray of light incident on the crystal of Iceland Spar is split into two rays, the " ordinary " and the " extraordinary," each of which travels in a different plane. In order that the incident ray may be transmitted in one plane, it is necessary to dispose of either the " ordinary " or " extraordinary " ray. The Nicol's Prism causes the " ordinary " ray to be totally reflected, allowing the free transmission of the " extraordinary " ray.

These types of prisms consist of rhombs of Iceland Spar, each of which is obliquely cross-cut symmetrical to the other. Faces polished and then luted by the cement whose index of refraction is greater than that of the " extraordinary " ray. This cross cut is of such an angle that total reflection of the " ordinary " ray occurs when the incident ray strikes the luted faces.

Our Nicol's Prisms are purchased from one manufacturer and are noted for their large polarizing field and their exceeding clarity. We have no hesitation in recommending either those which are carried in stock or those which we list herewith, free of duty.

78–95 NICOL'S PRISMS, luted by Canada Balsam, polarizing field of 22½ degrees.

	a	b	c	
Aperture	6	7	8	millimeters
Each	**$2.90**	**4.15**	**4.80**	

78–97 ——, same as above, but larger aperture.

	a	b	c
Aperture	15	20	25
Each, Duty Free . .	**$9.25**	**26.60**	**48.50**

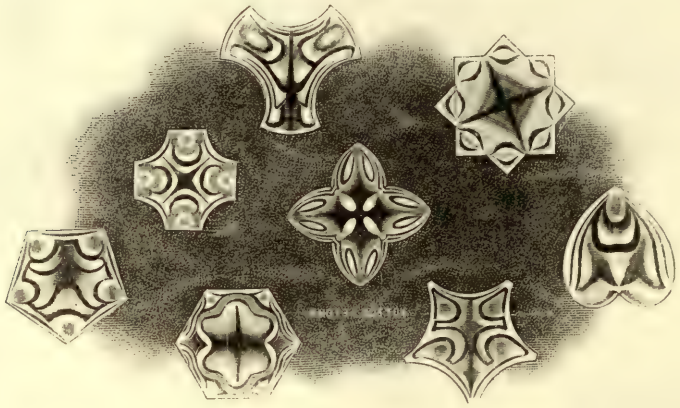
78–100 NICOL'S PRISMS luted with evaporated linseed oil. Aperture ⅓ of length, polarizing field 30 degrees.

	a	b	c	d	e	
Length	21	24	27	30	45	millimeters
Each, Duty Free . .	**$5.90**	**7.25**	**9.80**	**14.25**	**37.50**	

78–110 FOUCAULT'S PRISMS. The Foucault's Prism is a type of Nicol's Prism remarkable for its clarity the luting being a stratum of air. Polarizing field 8 degrees.

	a	b	c	d	
Aperture	20	25	30	35	millimeters
Each, Duty Free . .	**$7.25**	**14.50**	**24.00**	**29.50**	

OBJECTS FOR THE POLARISCOPE



No. 78–140

78–140 **UNANNEALED (IMPERFECTLY ANNEALED) GLASS SPECIMENS.** Suddenly cooled glass exhibits double refraction. In consequence such specimens will show different patterns under a beam of polarized light.
Set of eight selected specimens as above illustrated . . . . . Duty Free **$12.00**

SELENITE DESIGNS EXHIBITING MOST BEAUTIFUL COLORS IN POLARIZED LIGHT

78–153 **FOUR SELENITE PLATES** together in four colors **$2.15**
78–154 **CUBE,** three colors **2.70**
78–155 **OCTAHEDRON,** four colors **3.40**
78–156 **STAR,** six colors **5.00**
78–157 **BUTTERFLY,** most beautiful effects **6.15**
78–158 **BOUQUET,** highly recommended for its many strikingly beautiful colors . . . . . Duty Free **9.50**
78–165 **UNCUT MICA,** for individual adjustment, set of six plates of different thicknesses . . . . . **.90**
78–170 **MICA PLATE,** ¼ undulation, 40 millimeter aperture **2.25**
78–172 ——, ¼ undulation, 30 millimeter diameter **1.60**
78–174 ——, ¼ undulation, 12 to 15 millimeter diameter **1.00**
78–175 **MICA PLATE,** ½ undulation, 12 to 15 millimeter diameter **1.00**
78–180 **MICA COMBINATION,** after Noremberg, collection of six pieces . . . . . Duty Free **6.25**
78–181 ——, after Noremberg, in one preparation . . . . . Duty Free **7.15**
78–185 ——, after Ruesch, plates crossed under 60 degrees, turning right and left . . . . . Duty Free **7.25**
78–186 ——, after Ruesch, plates crossed under 45 degrees . . . . . Duty Free **7.40**
78–190 **MICA WEDGES,** two Mica Wedges, eight steps, each wedge arranged, one to turn over the other. Per pair . . . . . Duty Free **7.50**
78–195 **MICA WEDGES,** 16 steps, ¼ to 4 undulations, in form of the object bearer, 11 × 70 millimeters. Duty Free **6.90**
78–205 **SELENITE PLATES,** between two ¼ undulation mica plates, aperture 40 millimeters. Duty Free **3.25**
78–207 **SELENITE DOUBLE PLATE,** between two ¼ undulation mica plates, aperture 40 millimeters. Duty Free **3.75**
78–210 **SELENITE AND MICA COMBINATION,** according to Wright, magnificent colors, collection of six pieces . . . . . Duty Free **7.00**
78–211 ——, same as above, but collection of eight pieces . . . . . Duty Free **9.75**
78–220 **SELENITE PLATE,** for examining the character of double reflection by uni-axial crystal cuts, 40 millimeter aperture . . . . . Duty Free **6.25**
78–221 **SELENITE PLATES,** same as above, but 30 millimeter diameter . . . . . Duty Free **5.00**
78–225 **SELENITE PLATES,** in ¼, ¾, and ¾ undulations, laid one to the other, giving thirteen different steps, for diffused light . . . . . Duty Free **5.40**
78–226 ——, same as above, but for sodium light . . . . . Duty Free **5.90**

PROJECTION APPARATUS

"DELINEASCOPES"

OPAQUE MICROSCOPIC LANTERN SLIDE PROJECTION

It is with much satisfaction that we are the first to offer a complete line of projection apparatus in which the principles of projection have been scientifically worked out.

The entire field has been covered by three distinct models. The requirements for the various classes of work have been carefully considered, so that any educational institution desiring to do projection work will find in one of these models an outfit which will exactly meet its needs. For convenience the various types of instruments have been designated as follows: —

"DIRECT" DELINEASCOPE,

"MENISCUS" DELINEASCOPE,

"PRISM" DELINEASCOPE,

the above names being in a measure descriptive either of the kind of work for which the model is primarily designed or the distinctive feature embodied in that model.

OPTICAL PARTS

The success of the Delineascope is due to the selection of the best optical glass, worked to mathematical precision by the highest skill of lens-making art.

SPENCER CONDENSING SYSTEM. Our condensers are of ample proportions and superior in quality to those used in any form of projection apparatus on the market. The location is such as to utilize the greatest possible proportion of the cone of light. The cooling cell is, as the line drawings will indicate, of ample size and thus insures adequate cooling for high power and small aperture lenses.

SPENCER PROJECTION LENSES. The lenses used in all of the models are of the highest quality. The form of mounting is such as to entirely eliminate repair bills unavoidable where the rack and pinion adjustment is used. The spiral groove in the cylindrical surface of the mounting facilitates and simplifies all adjustment, this adjustment being secured by merely turning the lens on the horizontal axis.

SPECIAL FEATURES

Many important features will be found embodied in the various models of the Delineascope, — features which have been worked out with the greatest care and which are entirely new in projection apparatus of this class. A more definite description of some of these features will be obtained by reference to the illustrations, sectional drawings, and descriptions under the various models.

THE NEW SPENCER DISSOLVING SLIDE TRANSPOSER. Each of the models is provided with an improved Spencer Dissolving Slide Transposer, which gives on the screen an effect equivalent to the dissolving effect, but which is much more pleasing to the observer, entirely eliminating the eye strain unavoidable in dissolving projection work of other types. The entire operation is simple and positive, producing on the screen an effect not heretofore secured in any projection outfit.

ADJUSTMENT OF THE ARC. The illumination in all of the models is obtained by a correctly designed arc lamp which may be adapted either to alternating or direct current. The nature of the current should be clearly indicated in ordering. In the **"MENISCUS"** and **"PRISM"** models the various adjustments are all made by a single series of concentric buttons. In the **"DIRECT"** model the same adjustments are secured but in a slightly different manner. The **"MENISCUS"** and **"PRISM"** models have been designed so that the whole lamp is rotated by merely turning a handle "L," for the purpose of making possible and effective the various kinds of projection. For the further description of the advantages of this rotation see the outline drawings.

MICROSCOPIC ATTACHMENT. The microscopic attachment selected will depend upon the model used and the kind of work which one desires to do. On page **357** will be found a detailed description of these attachments, and they are further illustrated and described with the various models.

VERTICAL ATTACHMENT. This attachment may be used on either the **"DIRECT"** or **"MENISCUS"** models. It is readily interchangeable and easily operated. For detailed description see page **358**.

OPTICAL PARTS

CONDENSERS

Sharp definition cannot be secured without a good quality condenser. For this reason much more care has been taken in the calculation and construction of our condensers than lantern manufacturers have heretofore commonly used. The lens mounting is such as to allow free circulation of air around each lens and to permit of free expansion by heat without liability of breakage.

79–20 **PLANO-CONVEX LENS,** 4½ inches in diameter, illustrated immediately back of the lantern slide on all of the models **$1.50**

79–25 **PLANO-CONVEX LENS,** 4½ inches in diameter, illustrated immediately in front of the arc in "**DIRECT**" Delineascope **1.50**

79–30 **PLANO-CONVEX LENS,** 6 inches in diameter, illustrated immediately back of the water cooling cell in "**MENISCUS**" Delineascope **3.00**

79–45 **MENISCUS CONVEX LENS,** 5½ inches in diameter illustrated immediately in front of the arc in "**MENISCUS**" model **6.00**

79–60 **DOUBLE CONVEX LENS,** 8 inches in diameter, used as the front lens of the parallelizing system in the "**PRISM**" Delineascope **10.00**

79–65 **MENISCUS CONVEX LENS,** 6 inches in diameter, illustrated immediately in front of the arc in "**PRISM**" Delineascope **7.00**

79–75 **PLANO-CONVEX LENS,** 6 inches in diameter, illustrated immediately in front of the water cell in "**PRISM**" Delineascope **3.00**

79–80 **PLANO-CONVEX LENS,** 4½ inches in diameter, illustrated in front of above lens on "**PRISM**" Delineascope **1.50**

NOTE. It will be seen that the various models of projection apparatus have been designed with the one idea of giving the best results and having the greatest range of adaptation. The lenses employed have been especially designed for each type of instrument, thus insuring the best optical as well as the best mechanical results.

PROJECTION OBJECTIVES

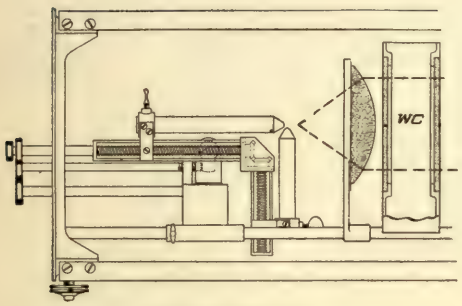
It has been fully realized that superior mechanical design and construction such as employed in the Delineascopes are useless unless the objectives are of equally high quality. The lenses used in all of the models have been mathematically calculated to produce a bright, uniformly illuminated field with sharp definition to the extreme edges. They are mounted in a heavy walled brass tube provided with a special spiral groove on the outside. This spiral groove is provided for focusing the objective. By this construction it may be noted that there are no delicate parts liable to get out of order. This will be readily recognized as a vast improvement over the old rack and pinion adjustment. Focusing is accomplished by revolving the lens on its optical axis.

The **choice of objectives** is a matter of prime importance. They should be selected with reference to the size of the picture desired and the distance from the screen at which the lantern is to be placed. The unsatisfactory results often obtained by those inexperienced in the use of a lantern is due in a large measure to the improper choice of suitable objective. The table below will serve to indicate the approximate size of picture in feet at various distances from the screen, using objectives of different equivalent foci. It is, therefore, necessary that one determine the distance at which the Delineascope is to be used from the screen and the size of the picture desired. The choice of objective may then be readily made from the table.

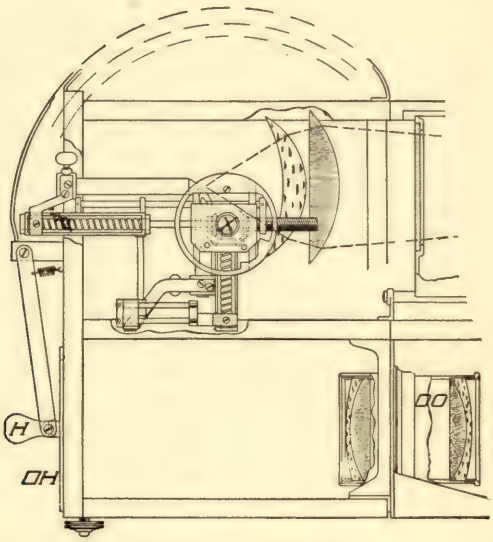
Equivalent focus of objective	Distance of the Delineascope from the screen in feet.								
	20	30	40	50	60	70	80	90	100
7 inches	8½	12¾	17	21					
8 "	7½	11	15	18½	22				
10 "	6	9	12	15	18	21	24		
12 "	5	7½	10	12½	15	17½	20	22½	
14 "	4½	6¾	9	10½	13½	15	17	19	21
16 "	3¾	5½	7½	9½	11	13	15	17	19
18 "		5	6½	8	10	11½	13	15	16½

79–100 **PROJECTION OBJECTIVE,** E. F. 7 inches, diameter 1⅝ inches **$7.00**
79–102 ——, E. F. 8 inches, diameter 1⅝ inches **7.00**
79–104 ——, " " 10 " " 1⅝ " **7.00**
79–106 ——, " " 10 " " 2½ " **15.00**
79–108 ——, " " 12 " " 2½ " **15.00**
79–110 ——, " " 14 " " 2½ " **15.00**
79–112 ——, " " 16 " " 2½ " **15.00**
79–114 ——, " " 18 " " 2½ " **18.00**
79–116 ——, " " 12 " " 4 " **75.00**
79–118 ——, " " 14 " " 4 " **75.00**
79–120 ——, " " 16 " " 4 " **75.00**
79–122 ——, " " 18 " " 4 " **75.00**

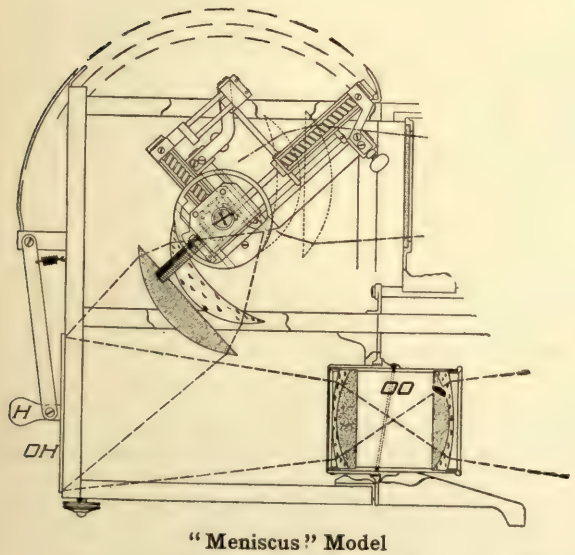
ILLUMINATING ARC



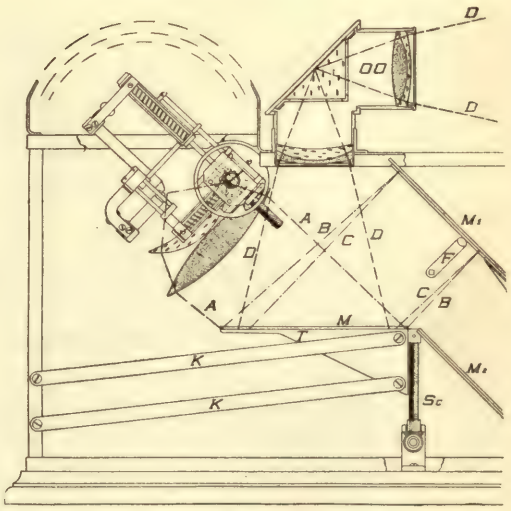
"Direct" Model



"Meniscus" Model
Arc in position for Direct, Vertical or Micro-projection



"Meniscus" Model
Arc rotated for Opaque Projection



"Prism" Model
Arc in position for Direct Projection

We desire to call particular attention to the improvements made in our projection arc lamp, in which the parts most likely to wear loose, get out of order, and cause difficulty in adjustment have been fully protected by suitable protecting surfaces, making the lamp in its present form as durable and permanent as the housing itself.

The design of this arc lamp is correct. It is adapted either for the alternating or direct current, and in ordering it is necessary to state the nature of the current. In **"MENISCUS"** and **"PRISM"** models all adjustments are secured by a single series of concentric buttons, which give to the carbons the varied adjustments required. In the **"DIRECT"** model adjustments are similarly secured. A valuable feature of the **"MENISCUS"** and **"PRISM"** models is the ease with which the lamp system may be rotated to meet the conditions of each type of projection. By reference to these models it may be noted that by simply turning a handle the arc may be rotated to secure the different results. In any position all arc adjustments are secured by the concentric buttons.

79–135 **HAND FEED ARC LAMP,** as used in **"Direct" Delineascope** for direct current **$15.00**

79–140 ——, same as above, for alternating current **15.00**

RHEOSTATS. See page **364.**

NEW SPENCER DISSOLVING SLIDE TRANSPOSER

As may be noted in our models, the method of handling and transposing the slides is a radical departure from the conventional form and eliminates entirely the necessity of separate and detached slide holders. Each outfit has embodied the New Dissolving Slide Transposer.

In the dissolving transposer the slide about to be thrown upon the screen is placed upon the horizontal table marked " S_1 " (see Fig. 1). By simply turning the lever " L," the slide is raised to a vertical position "S_2," quickly but steadily moved into position, while at the same instant the slide which has been previously projected on the screen is automatically lowered to position " S_3." This change takes place so rapidly yet quietly that the observer's eye does not have time to look for the change and consequently the eye strain is entirely avoided.

The dissolving effect is practically perfect, the result being more pleasing than that produced with the double dissolving projector. As a practical feature for lecture work this is a most important improvement in the science of projection.

The new transposer is supplied on all the models. Its advantage over all the old types may readily be noted in that transposition of the slides is made from the same side of the apparatus in a position most convenient for the operator.

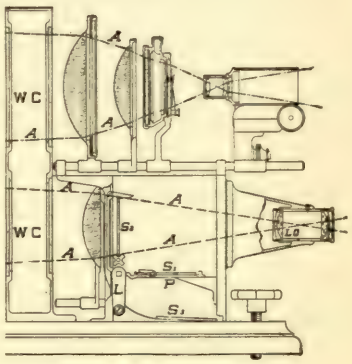
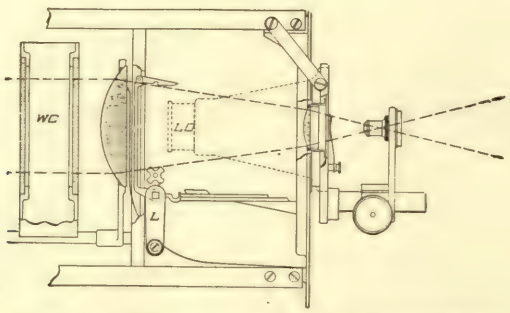


Fig. 1

MICROSCOPIC PROJECTION



No. 79–175 (In use on "Direct" Delineascope)

Provision for microscopic projection has been made on all our models. Any model may be furnished fully equipped for microscopic projection. The prices of these equipments will be found under the special listings of the model.

The demands of different classes of work are varying, and for this reason there have been designed four different types of microscopic attachments. These microscopic attachments are adapted for use on either the **" DIRECT "** or **" MENISCUS "** models. The **" PRISM "** model is furnished completely equipped for microscopic projection.

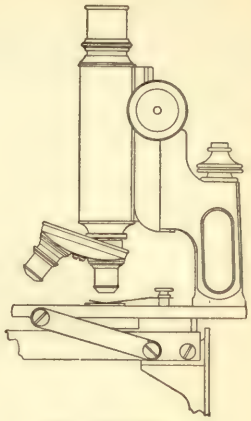
79–175 SIMPLE MICROSCOPIC ATTACHMENT, with **Substage Condenser**. This attachment is illustrated on **" DIRECT "** Delineascope. It has a substage 4½ inches square, face distance 2½ inches from center of the stage to the supporting arm. It is provided with rack and pinion adjustment and is of high-grade workmanship throughout. This attachment may be used on either **" DIRECT "** or **" MENISCUS "** models **$15.00**

79–180 MICROSCOPIC ATTACHMENT, same as above, but supplied with **microscope body tube** for carrying an eye-piece. It is provided with rack and pinion adjustment and substage condenser. This attachment may be used on either the **" DIRECT "** or **" MENISCUS "** models **20.00**

NOTE. As Nos. **79–175** and **79–180** are provided with rack and pinion adjustment only, we recommend with them the use of relatively low power objectives.

79–190 FINE ADJUSTMENT MICROSCOPIC ATTACHMENT, for use on either "**DIRECT**" or "**MENISCUS**" models. This attachment is substantially our Compound Microscope No. **B1–40,** with suitable support for attaching it to the lantern in place of the regular supporting base. Full provision is made for the double nose-piece and a variety of objective lenses and eye-pieces. The instrument has both rack and pinion and fine adjustment, permitting the use of high power objectives. Stage 4½ inches, distance from optical axis to supporting arm 2½ inches, body tube 1 9/16 inches in diameter. Provided with substage condenser **$40.00**

79–195 SUBSTAGE WATER CELL, for attachment to the above **5.00**



No. 79–190

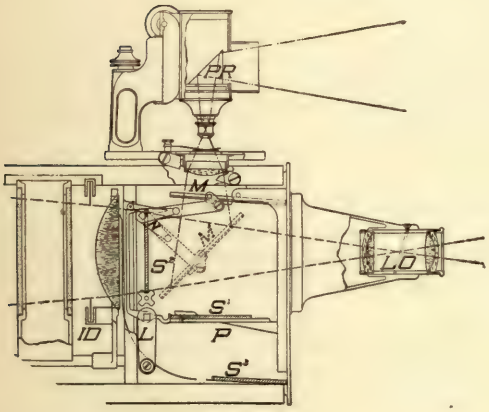


Fig. 1

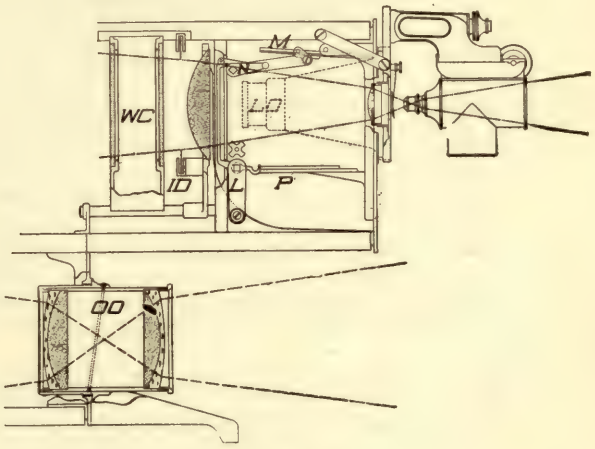


Fig. 2

COMPOUND REFLECTING MICROSCOPE ATTACHMENT. This attachment has been especially designed for use on the "**MENISCUS**" model. It may, however, be used equally well on the "**DIRECT**" model. The method of support, the handle arm, coarse and fine adjustment, are much the same as No. **79–190,** but it has a very decided improvement in the removable total reflecting prism which especially adapts it to the "**MENISCUS**" model.

The use of the total reflecting prism in connection with the attachment gives the additional advantage of using the attachment as a vertical projector, or, when used in position as noted in Fig. **2,** it becomes at once a regular micro-projector and camera lucida, as in this position the prism may be so adjusted that a portion of the rays will be intercepted and carried to the table directly under the instrument. The remainder will pass on to the screen through the regular projecting system. This feature will be found very important where a permanent record of the development of a specimen is desired.

A special cooling cell is supplied on the under side of the stage, the upper glass wall of which is flush with the top of the stage. In this position the microscope slide is allowed to come into direct contact with the cell, which is the best possible guarantee against over-heating of the cell.

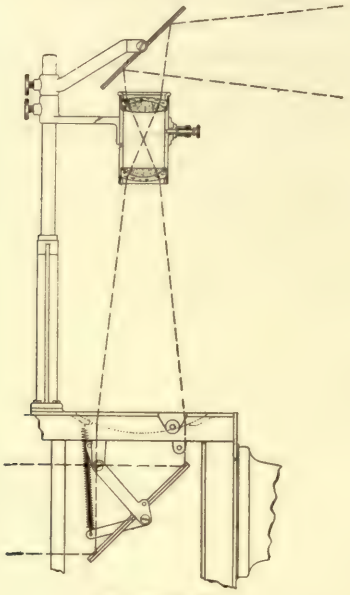
When the attachment is ordered at the same time as the Delineascope, an Iris diaphragm is placed between the converging lenses of the condensing system and the light. This not only controls the angle of the cone of light, but cuts out much of the superfluous heat.

79–205 MICRO-ATTACHMENT as described, with substage water cell, condensing system, large Iris diaphragm attached to the converging lens, triple nose-piece, prism on separate mounting in body tube, adapter and draw tube for projection ocular, — projection ocular included **$100.00**

79–206 PROJECTION LENS, 6-inch focus, mounted on separate mountings as described, used for converting the micro into a vertical attachment **10.00**

79–210 ACHROMATIC OBJECTIVE, E. F. 16 mm. (⅔ inch) **5.00**
79–212 " " E. F. 8 mm. (⅓ inch) **8.00**
79–214 " " E. F. 4 mm. (1/6 inch) **8.00**
79–216 " " E. F. 3 mm. (⅛ inch) **8.00**
79–218 ACHROMATIC OBJECTIVE, OIL IMMERSION, E. F. 2 mm. (1/12 inch) **27.00**

VERTICAL PROJECTION APPARATUS



No. 79–225

Our vertical attachment is designed for the ready projection on the screen of objects such as biological specimens in solution, certain classes of physical experiments, etc. which must be handled in the horizontal position. Special provision is made in the design of the lantern so that the vertical attachment, if not ordered with the lantern, may be readily attached and adjusted. The design is such that we can guarantee perfect fit and adjustment on any of our models.

79–225 **SIMPLE VERTICAL PROJECTION ATTACHMENT.** This form utilizes the projecting lens of ordinary type in conjunction with the mirror which is supplied as a part of the apparatus. It will be found satisfactory for most school work. If greater definition is required, we recommend No. **79–230** following.

Complete with mirrors, ready for attachment to any of our models, but without objective **$15.00**

79–230 **PRISM VERTICAL PROJECTION ATTACHMENT " A."** This attachment is similar to the above, but provided with a total reflecting prism and special projecting lens 1⅝ inches in diameter. The advantages of the total reflecting prism will be apparent to those who are familiar with the difference in the character of reflected light coming from a mirror and that coming from a total reflecting prism.

Vertical attachment complete with objective, ready for attachment to any of our models **35.00**

79–235 **PRISM VERTICAL PROJECTION ATTACHMENT " B."** Same as above, but with special projecting lens 2½ inches in diameter **50.00**

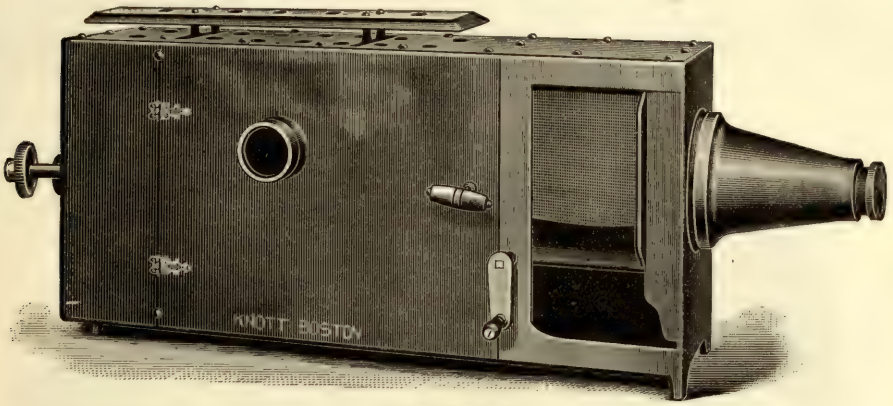
79–240 **PRISM VERTICAL PROJECTION ATTACHMENT " C."** This attachment is designed for use on the **" PRISM "** Delineascope. It is especially designed for experiments conducted in a large way, as will be noted from the specifications. Special provision has been made in the construction of the apparatus for its rigid attachment to the water cell, making it an integral part of the complete projection outfit.

The attachment includes provision for the inside directing mirror and a 6-inch plano-convex lens, on the surface of which the transparent objects are to be placed.

Rods for supporting the special 2½-inch projection lens and a total reflecting prism are furnished. The method of mounting is much the same as in No. **79–230**. The focusing is accomplished by means of two side rod supports. The apparatus has been designed with special reference to its use in conjunction with the vertical micro-projection apparatus of the same design. This greatly increases the value of both instruments.

Complete, with 6-inch condensing lens and projection objectives carrying the total deflection between them **50.00**

"DIRECT" DELINEASCOPE



Patent Pending

This model of projection apparatus is compact, easily operated, and designed for all kinds of projection where transmitted rather than reflected light is used. Its substantial construction, perfect adjustment, and complete adaptability to lantern slide projection, projection of microscopic objects, and vertical projection will be greatly appreciated. We desire to call attention to important facts which in new instruments are often passed over. Illustration at the bottom of the page shows the ready adaptability for a rapid change from direct projection of lantern slides or to direct projection of microscopic slides, requiring only an instant to swing a projection objective to one side and bring down the microscopic attachment. The position of the latter, when direct projection is used, is shown in the line drawing. This model is equipped with the Spencer Dissolving Transposer, with the water cell and the improved illuminating arc.

79–275 **"DIRECT" DELINEASCOPE OUTFIT "A,"** for **lantern slide projection** only, complete with No. **79–104** projection objective, and illuminant. Will give a 9-foot picture at distance of 30 feet from screen **$35.00**

79–278 **"DIRECT" DELINEASCOPE OUTFIT "B,"** same as above, but with No. **79–106** projection objective **43.00**

79–279 **DIRECT DELINEASCOPE OUTFIT "C,"** same as above, but with lenses for giving a 16½-foot picture at a distance of 100 feet **46.00**

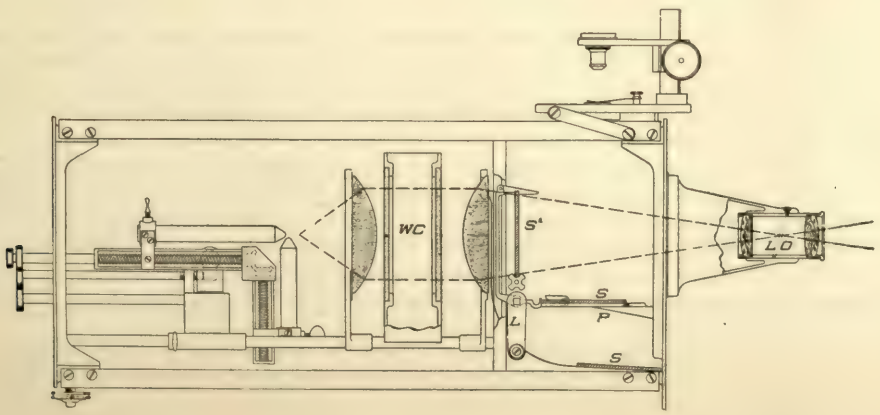
79–280 **"DIRECT" DELINEASCOPE OUTFIT "D,"** for **lantern slide projection only,** complete with No. **79–104** projection objective, illuminant, No. **79–425** rheostat, and No. **79–552** Screen 8 × 8 feet **46.00**

79–285 **"DIRECT" DELINEASCOPE OUTFIT "E,"** for **lantern slide** and **microscopic projection.** This outfit is the same as No. **79–275** with the addition of our No. **79–175** simple microscopic attachment **50.00**

79–290 **"DIRECT" DELINEASCOPE OUTFIT "F,"** same as No. **79–280,** but with simple microscope attachment No. **79–175** **61.00**

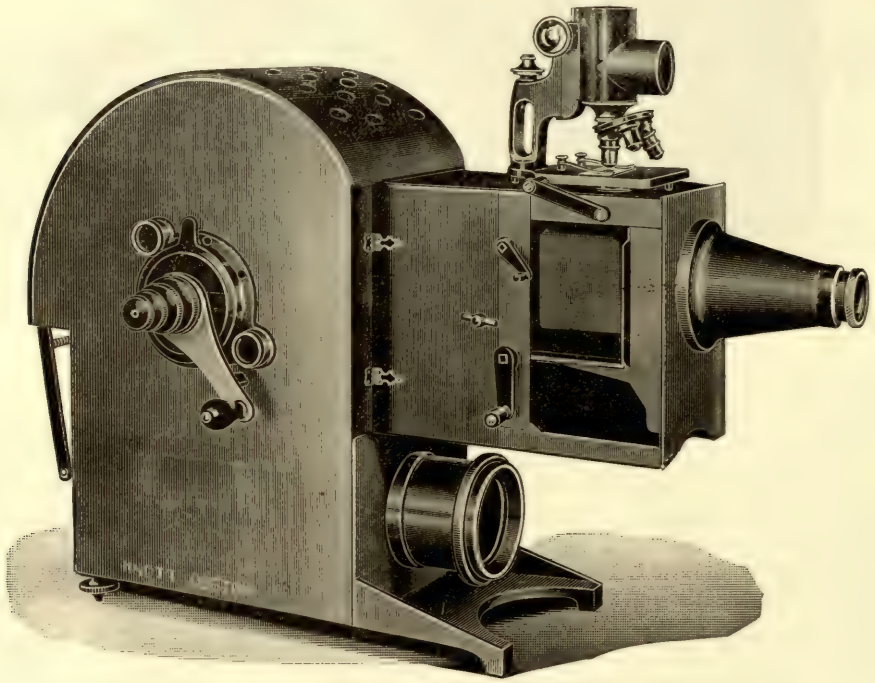
79–225 **SIMPLE VERTICAL ATTACHMENT,** added to any of the above outfits, extra **15.00**

79–230 **PRISM VERTICAL ATTACHMENT,** added to any of the above outfits, extra **35.00**



"MENISCUS" DELINEASCOPE

OPAQUE LANTERN SLIDE VERTICAL MICROSCOPIC PROJECTION



Patent Pending

This model is provided with all the latest improvements previously described. Without any accessory attachments it is adapted for both opaque and lantern slide projection. For lantern slide projection the arc is kept in normal position. (See Figure **1**.) For opaque projection the illuminating arc is rotated by means of the handle to position shown in Figure **2**. The object for opaque projection is held by suitable clamps to the opaque holder "OH." A change from lantern slide to opaque projection or vice versa is readily secured by the simple operation of turning a handle.

Any microscopic attachment listed on page **357** may be used in microscopic projection. No. **79–205**, Compound Reflecting Microscope Attachment as illustrated "in full" and also in Figures **1** and **2** is advised, as particularly adapted to this class of instrument. As illustrated "in full" and in Figure **1** the image is greatly improved by causing the light to pass through the total reflection prism. In position as in Figure **2** the total reflection prism may be drawn out or used part way in the tube. In the latter case the attachment is used as a "Camera Lucida" or Drawing Microscope.

As may be noted from Figure **1**, lantern slide and microscopic projection are interchangeable without movement of the arc, the change in this case being secured by the movement of a small handle which operates the mirror "M."

Opaque projection is secured by rotating the arc to position as noted in Figure **2**. It can therefore be seen that three different types of projection can be secured in the same outfit by the mere operation of turning the proper handles. In each case a beautiful dissolving effect is secured.

A vertical attachment recommended for this model is No. **79–230** Prism Vertical Attachment. It may be attached in a moment in place of the microscopic attachment above. **Vertical, lantern slide, microscopic,** and **opaque projection** may then be secured by a movement of mirrors and arc in a manner as above described.

We desire to call attention to the fact that this is the only outfit in which all types of projection are made simple and where change of one type of projection to the other is secured without a change in the direction of the optical axis.

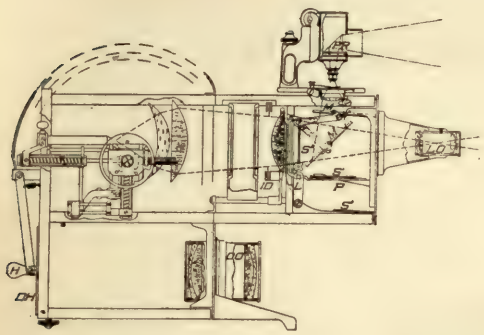


Fig. 1

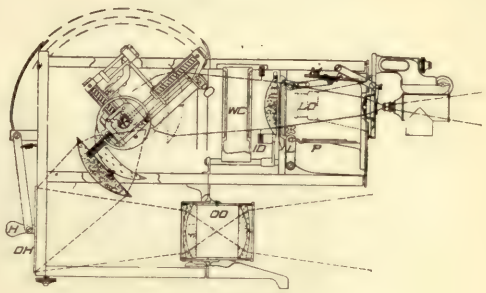


Fig. 2

FEATURES

The greatest care is exercised in securing a universal instrument in which all mechanical and optical arrangements have been perfected. We request that the following important features be noted:—

1. The large, well-ventilated, light-tight housing.
2. Mechanical construction, permitting of complete operation from one side of the apparatus; all parts conveniently located.
3. Arc adjustments and methods of rotating arc to secure the different types of projection.
4. Efficient protection of parts from the heat of the arc.
5. The simple, effective, easily accessible means of changing from one type of projection to another.
6. The Spencer Dissolving Transposer and mechanical arrangement of all parts and attachments to give the beautiful dissolving effects typical of the Delineascope.
7. In opaque projection, the large, brilliantly illuminated area and the provision for focusing the opaque projective to and from the object.
8. The large lenses used throughout the optical system are of the highest quality, mathematically calculated and scientifically constructed.
9. Ease with which microscopic attachment is fitted; its method of use either vertical or horizontal; it is entirely out of the way when not in use.
10. The ease with which the vertical attachment may be fitted.
11. The completeness of the full outfit; the ready, easy, efficient change from one type of projection to the other.
12. The rigid, substantial structure; the scientific appearance; and the durable and handsome finish.

79–325 **" MENISCUS " DELINEASCOPE " A,"** with objective for opaque projection 4 inches in diameter, 12 inches equivalent focus, and with lantern slide objective 1⅝ inches in diameter and 10 inches equivalent focus **$125.00**

79–335 **" MENISCUS " DELINEASCOPE " B,"** same as above, but with objective for opaque projection 4 inches in diameter, 16 inches equivalent focus **125.00**

79–345 **" MENISCUS " DELINEASCOPE " C."** Same as No. **79–325**, but with lantern slide objective 2½ inches in diameter and 10 inches equivalent focus **133.00**

79–355 **" MENISCUS " DELINEASCOPE " D."** Same as above, but with objective for opaque projection 4 inches in diameter, and 16 inches equivalent focus **133.00**

79–205 **COMPOUND REFLECTING MICROSCOPE ATTACHMENT,** for use as illustrated on **" MENISCUS "** model above. Complete ready for attachment **100.00**

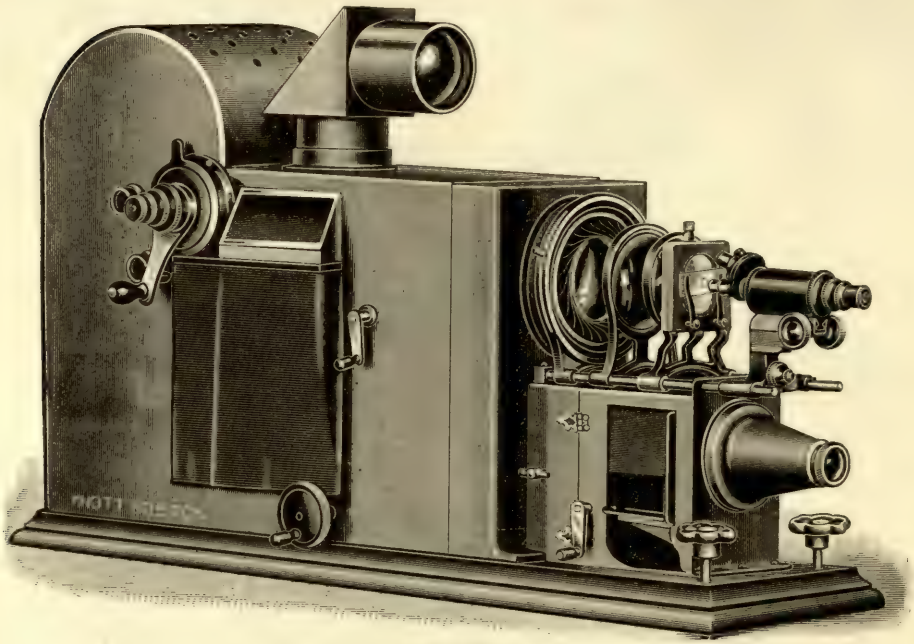
79–190 **FINE ADJUSTMENT MICROSCOPIC ATTACHMENT,** with **Substage Condenser,** complete ready for attachment to **" MENISCUS "** model above **40.00**

79–230 **PRISM VERTICAL ATTACHMENT,** complete with objective, ready for attachment to **" MENISCUS "** model above **35.00**

RHEOSTATS. See page **364.**

SCREENS. See page **366.**

"PRISM" DELINEASCOPE



Patent Pending

Considering the adaptability and efficiency of the **" MENISCUS "** model, it might well be asked why an instrument of larger size should be offered for educational work. In producing the **" PRISM "** model the same essential features as in the **" MENISCUS "** have been retained, but worked out on a plan which permits of projections being conducted on a larger scale, using, as will be noted, a larger condensing system, larger prisms and lenses, and many other additional features such as iris diaphragms, substage cooling tanks, and an exceptionally large general cooling tank which may be used in all kinds of projection work. In fact, the apparatus listed above represents the highest attainments in opaque, lantern slide, microscopic, and vertical projection. When one considers the results possible with this instrument, the ease of operation, and the fact that the entire instrument is only 44 inches long and 12 inches wide, it is then only that its attainments will be fully appreciated.

The great success of the instrument as an **opaque projector** is due in no slight degree to the use of total reflecting prisms, in combination with the 4-inch lens. This, together with the revolving arc, does away entirely with the use of mirrors, thus forming on the screen a rectified image. This has heretofore been obtained only by the use of mirrors which confuse the image and absorb the light.

The **intensity of illumination** has been greatly increased by the use first of an 8-inch condensing lens, coupled with a meniscus lens 6 inches in diameter, giving an illuminated area on the opaque table 8 × 10 inches, and secondly by the use of a secondary mirror " M_1," shown in Figure **1**, which serves to carry any light not previously utilized into the opaque object, not only adding greatly to the intensity of illumination but also giving to the image a clearness and absence of shadows not found in any other form of projection apparatus.

The **cooling tank,** extending from top to bottom of the instrument, contains water sufficient to permit use of the apparatus during an entire laboratory period without danger of overheating.

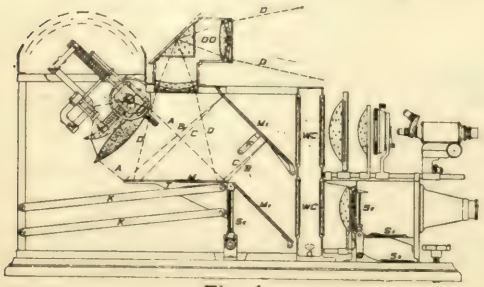


Fig. 1.

The **focusing of opaque objects** is accomplished by means of a most convenient lift. As will be noted in the illustration, the operator can easily view the opaque object on the table through the inclined colored glass window and point out by means of a small pointer any special features to which he desires to call attention, the pointer being projected on the screen with the image.

Lantern slide projection utilizes the new Spencer Dissolving Slide Transposer as previously described and used in the **" DIRECT "** and **" MENISCUS "** models. Focusing for lantern slide projection is secured by means of turning the projection lens on its horizontal axis.

Microscopic projection is secured in a way that will be noted in Figure **2,** the rays passing straight from the condensing system to the secondary condensing system, through the water cell, through the substage condenser and substage water cell into a projection microscope. By means of the two cooling tanks thus noted, together with properly worked out condensers, the highest power objectives may easily be used.

The microscopic attachment designed for this instrument is one especially adapted to this model.

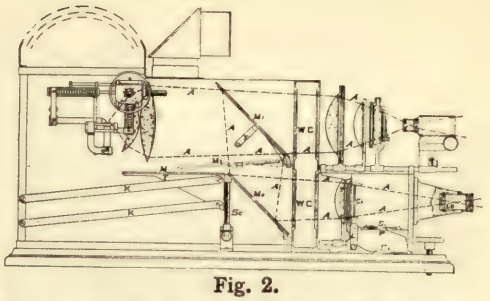


Fig. 2.

A **most pleasing dissolving effect** is a most important feature of this outfit. The ease and smoothness with which the change from one kind of projection to another is made will delight the lantern enthusiast. This beautiful dissolving effect is made possible by the movement of mirrors on carefully adjusted bearings, all operations being made from one side of the instrument by handles conveniently placed.

This model has been designed to meet every requirement of scientific projection. The mechanical and optical features have been the results of the most careful consideration. Mechanics and lens makers have combined to produce in this model a universal projector combining all the best features heretofore utilized in projection work, with the additional improvements resulting from exhaustive utility tests.

FEATURES

1. A substantial, scientific design: all operations conducted from one side and all parts conveniently located.
2. Effective protection of working parts from heat of the arc.
3. Perfect dissolving effects in lantern slide projection due to the new Spencer Dissolving Slide Transposer; beautiful dissolving effect in changing from one type of projection to another by means of carefully placed mirrors.
4. The exceptionally large and intensely illuminated area secured for opaque projection.
5. The easily accessible opaque table provided with mirror background.
6. Total absence of lights and shadows in opaque projection due to the reflected light from properly placed mirrors.
7. Adaptability of all parts to perfect opaque projection.
8. Clear, sharp definition of image possible, due to the passage of light through the prism.
9. The completeness and mechanical perfection of all parts entering into lantern slide projection; the convenient location of the lantern slide compartment: a large water cell; easily focused projection objective; and the new Spencer Dissolving Slide Transposer.
10. Efficient microscopic attachment, especially adapted and designed for the model: the stage and tube are on separate movable standards. The condensers also are on movable standards, the 6-inch condenser being provided with an iris diaphragm. The stage is large; the tube of such construction that any microscope objective lenses from the highest to the lowest powers may be used.

The **" PRISM "** Delineascope is furnished only with the complete outfit illustrated, including in addition to the usual features for an opaque instrument the complete microscope attachment with iris diaphragm for the 6-inch lens, a secondary pair of condensing lenses, a substage condenser, and substage cooling tank. This attachment if furnished separately would cost **$125.00**.

The total reflecting prism system furnished with this outfit consists of a 4-inch prism constructed and polished to the highest possible degree of accuracy. The price of this prism system if furnished separately would be **$140.00.**

We desire to call attention to the high quality of these optical systems before making the listings as follows. In comparing prices, therefore, with projection outfits either of foreign or American manufacture we request that the perfection of our optical parts be taken into consideration.

79–375 **" PRISM " DELINEASCOPE,** with objective for opaque projection 4 inches in diameter, and 14-inch equivalent focus, with prism between the lenses; with lantern slide objective 1⅝ inches in diameter and 10-inch equivalent focus; and with complete microscope attachment with condensers, water cell, etc., but without microscopic objective and eye-pieces **$400.00**

79–380 ——, same as above, but with objective of 16-inch equivalent focus substituted for the 14-inch objective **400.00**

79–385 ——, same as above, but with lantern slide objective 2½ inches in diameter substituted for the objective 1⅝ inches in diameter **400.00**

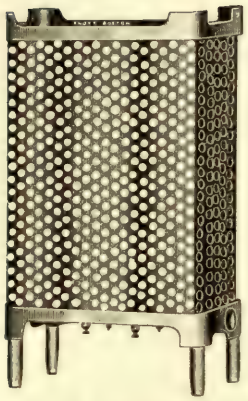
79–390 ——, same as No. **79–380,** but with lantern slide objective of 2½-inch diameter substituted for the one of 1⅝-inch diameter **400.00**

RHEOSTATS. See page **364.**

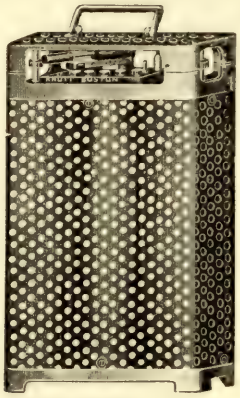
SCREENS. See page **366.**

MICROSCOPE OBJECTIVES. See page **357.**

RHEOSTATS



No. 79–425



No. 79–435

The uncertainty as to the nature of the current supply and conditions of operation of projection outfits have necessitated listing our outfits both with and without the Rheostat and Screen. In placing orders, therefore, great care must be exercised to give full information concerning all conditions of operation and current supply available.

Our Rheostats have been designed with special reference to projection work on the assumption that at times at least large amperage is to be used and that frequent and rapid changes to low amperage must needs be made. For this reason the switches on our adjustable types are made much more substantial than are usually supplied, and so designed that they cannot get out of order. We have used standard types of *high resistance wire*, as no material has yet been found which is superior to it for the severe work which projection entails. Both the size and resistance of the wire have been carefully proportioned so that the necessary heating resulting from large amperage will do no injury.

In ordering specify clearly the voltage of the current and whether it is A. C. or D. C.

79–425 **RHEOSTAT,** 15 amperes, 110 volts, fixed form, for direct current **$7.00**

79–430 ——, 15 amperes, 220 volts, fixed form, for direct current **18.00**

79–435 **ADJUSTABLE RHEOSTAT,** 15 to 40 amperes, 110 volts, for direct current **27.00**

79–445 **RHEOSTAT,** 15 amperes, 110 volts, for alternating current **7.00**

79–450 ——, 15 amperes, 220 volts, for alternating current **18.00**

79–455 **ADJUSTABLE RHEOSTAT,** 15 to 40 amperes, 110 volts, for alternating current **27.00**

LANTERN TABLES

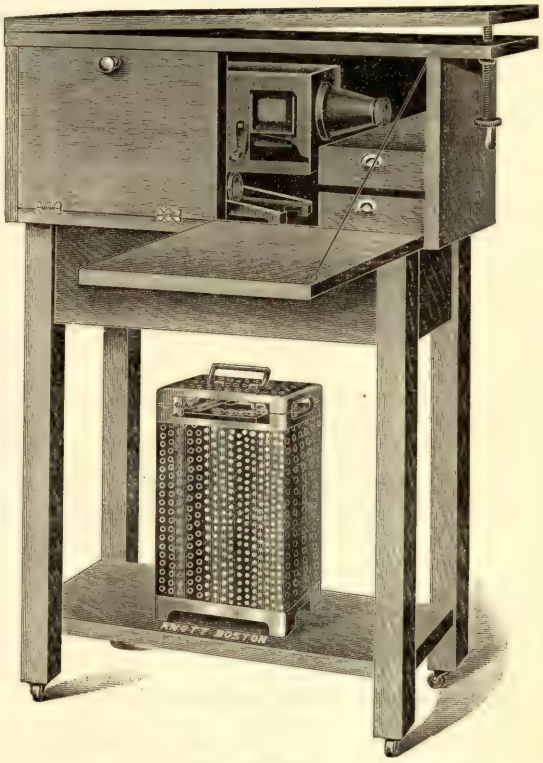
In order to meet the varying requirements, we offer two types of tables. Both are of heavy, substantial construction, able to hold the outfit rigid and to provide adequate working space. For "**DIRECT**" Delineascope we recommend the simple form of table provided with shelf for handling slides and general working material, the space under the shelves being ample for the rheostat.

79–475 LANTERN TABLE, simple form, provided with shelf, space for rheostat, mounted on castors **$10.50**

COMBINATION STORAGE CABINET AND LANTERN TABLE, made in two sizes, designed for the convenient use and adjustments of models "**MENISCUS**" and "**PRISM,**" combining with the working table convenient space for lantern and storage of slides. The doors closing the cabinet are hinged with substantial hinges and chain supports so that when in use one or both doors may serve as a most convenient rest for slides, opaque objects and other working material.

79–477 STORAGE CABINET and LANTERN TABLE for Model "**MENISCUS**" **$27.50**

79–480 STORAGE CABINET and LANTERN TABLE for Model "**PRISM**" **$34.50**



No. 79–477

ACETYLENE LAMPS

When the electric current is not available, satisfactory results in the projection of lantern slides can be obtained with the Acetylene Lamp. It is not, however, recommended for opaque work, or for a smaller diameter projection objective than 2½ inches in diameter at a distance not greater than 30 feet. Increased illumination has resulted from our method of placing a silvered mirror back of the Acetylene Burner. (See illustration.) The gas consumption is 1¼ cubic feet per hour.

No. 79–500

79–500 ACETYLENE LAMP with silvered mirror **$8.00**

GAS SUPPLY

For the gas supply of the above Acetylene Lamp we recommend the use of compressed acetylene gas, preferably such as furnished by the Prest-O-Lite tank.

79–515 PREST-O-LITE TANK, capacity 30 cubic feet **$18.00**

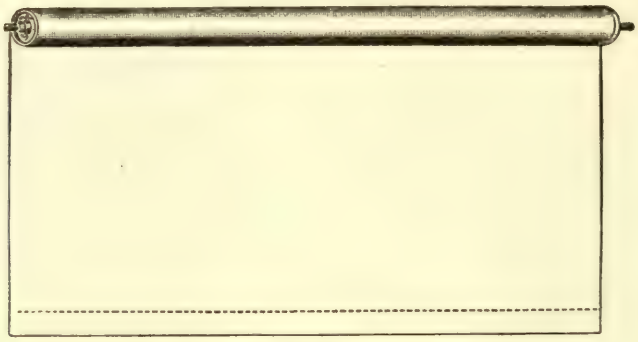
79–520 PREST-O-LITE TANK, capacity 40 cubic feet **25.00**

NOTE. The tank may be refilled or exchanged for a new filled tank at any automobile supply store at the same price which we are obliged to charge. In many instances a saving in transportation will thus be effected.

Cost of refilling No. **79–515** Prest-O-Lite Tank **$1.25**

Cost of refilling No. **79–520** Prest-O-Lite Tank **1.50**

PROJECTION SCREENS



No. 79–575

In selecting the material for our screens, we have had in mind the necessity of intercepting as large a percentage of the light as possible on the front surface. Should it be desirable to locate the lantern back of the screen, as is sometimes done in lantern slide projection, we should be so notified when the order is placed.

The size of the screen to be selected will depend upon the range of the projection lens and the distance between the lantern and the screen. Complete information will be found in the table of lenses given on page **354**.

79–550 **UNMOUNTED MUSLIN SCREENS.** These screens are made from the best quality of bleached muslin selected for texture and tone. Each screen is hemmed around its entire edge, with rings set at equidistant spaces of approximately two feet, the corners being turned for additional reinforcement. Size 6 × 6 feet **$3.00**

79–552 ——, 8 × 8 feet **4.00**

79–553 ——, 10 × 10 feet **4.50**

79–554 ——, 12 × 12 feet **7.00**

79–558 ——, 15 × 15 feet **10.00**

79–560 ——, 18 × 18 feet **12.00**

79–575 **OPAQUE PROJECTION SCREENS WITH SPRING ROLLERS.** In the making of these screens, we use a heavy pearl white fabric unusually opaque, adapted alike for both lantern slide and opaque projection. Only the best Holland spring rollers are used, and the springs and the size of the rollers graded according to the size and weight of the screen to be used. On the larger sizes of screens the metal rollers only are employed.

	a	b	c	d	e	f
Size	6 × 6	8 × 8	10 × 10	12 × 12	15 × 15	18 × 18 feet
Each	**$4.00**	**8.00**	**15.00**	**20.00**	**24.00**	**30.00**

PROJECTION ACCESSORIES

79–600 **ADJUSTABLE DIAPHRAGM,** giving a variable width parallel beam, adapted to any of the Delineascope Models **$4.50**

79–605 **MULTIPLE PENCIL RAY ATTACHMENT,** so designed that five sizes of cylindrical beam parallel rays may be obtained **4.75**

BOTTLE PRISM, for spectrum projection. See Section **74.**

GLASS CELLS, for study of refractive index of liquids. See Section **74.**

79–625 **GLASS CELLS,** for Electrolysis Projection, provided with electrodes. Designed to use with either model of the Delineascope **6.50**

79–650 **TOTAL REFLECTION PRISM,** 50-millimeter face as used in Vertical Projection Attachment, No. **79–230** **20.00**

79–655 **TOTAL REFLECTION PRISM,** 100-millimeter face as used in "**PRISM**" **DELINEASCOPE** . . **140.00**

90–40 **THEATRE CABLE,** for 40 amperes current; advisable for use in lantern projection. This cable consists of two conductors, flexible, cotton wrapped, rubber covered, braided, twisted together with filler, and finished with two weather-proof braids . . . . . Per Yard **1.05**

79–680 **CARBON RODS,** for lantern work, cored.

	a	b	c
Length	6	6	6
Diameter . . .	⅜	½	⅝
Per Dozen . . .	**$0.75**	**.75**	**.75**

79–700 **LANTERN SLIDE BOX,** a carefully constructed box of polished hardwood for holding fifty slides in separate compartments and arranged with suitable cover and catch for carrying **1.50**

SPECIAL LANTERN SLIDE LISTS on request.

ACCESSORIES FOR MAKING LANTERN SLIDES

For the convenience of those who prefer to make their own slides we offer a carefully selected list of material which will be found necessary in the work.

79–750 **THE IDEAL LANTERN SLIDE CAMERA,** by which lantern slides can be made from a reduction of a 4 × 5 negative. As it is a fixed focus camera, sharp slides only can be the result. The front plate is made reversible so as to accommodate vertical or horizontal negatives. There is no focusing, no centering, and no waste of plates.

Complete $5.00

79–755 **LANTERN SLIDE PLATES,** Lumière's . . . . . Per Dozen .55

79–760 ——, Seed's . . . . . Per Dozen .40

79–765 **LANTERN SLIDE COVER GLASSES,** of clear French glass, uniform thickness and density. Per Dozen .32

79–770 ——, first class Bohemian . . . . . Per Dozen .48

79–775 **LANTERN SLIDE MATS,** Olmstead design . . . . . Per Hundred .75

79–780 **LANTERN SLIDE BINDERS,** extra quality, black in roll . . . . . Per Roll .50

79–785 **CONSECUTIVE SLIDE NUMBERS,** gummed and perforated in sheets, each sheet having 200 numbers. Range from 1 to 10,000 may be secured. Sold only in multiples of 200.

Per sheet of 200 numbers .20

79–790 **ALADDIN PLATE RACK,** made entirely of metal, well protected from rust, will hold twelve plates in any size from 3½ to 10 inches . . . . . Each .30

79–795 **LANTERN SLIDE VISE,** for holding the slide and plate rigidly together, permitting the free rotation of the two while the plate is being bound . . . . . Each .60

79–800 **LANTERN SLIDE CONTACT FRAME,** permitting any size negative from 5 × 7 to 3½ × 3½ to be used. The opening in the frame is of the standard lantern size dimensions . . . . . Each .50

79–805 **PHOTOGRAPHIC ROLL,** first quality rubber, on hardwood cylinder with cylindrical bearing, 6 inches long . . . . . Each .25

79–810 **DEVELOPING TRAYS.** Corners of these trays are raised, preventing negative from being scratched by sediment in the bottom.

	a	b	c	d
Size	4⅜ × 5½	5¾ × 8½	7 × 9	8½ × 10½
Each	$0.12	.30	.45	.60

79–815 **DARK ROOM LANTERN,** with perfect ventilation. Volume of light ample for ordinary work. Combination of ruby and orange glass, to be used singly or in combination. Entire regulation from the outside 80

79–820 **ELECTRIC DARK ROOM LANTERN,** fitted complete with a 16-candle power incandescent lamp with wiring connections and three glasses, orange, ruby, and ground glass, either of which may instantly be removed, adapting the light to the class of work in hand. The entire shield with colored glasses may instantly be removed for obtaining white light when desired.

Complete with cord and Edison plug 2.50

MAGNETISM AND STATIC ELECTRICITY

MAGNETS

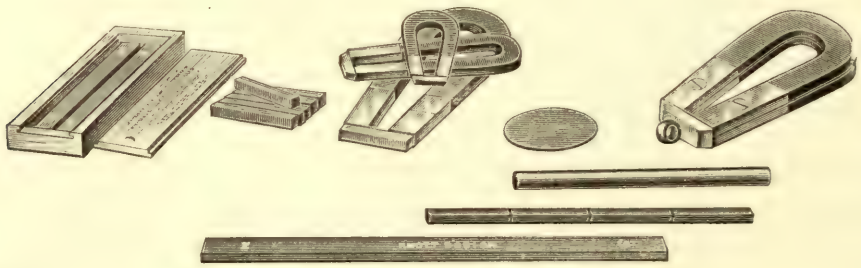
Our line of apparatus illustrative of Magnetism and its various properties has been selected with great care. Our magnets are of the **best quality steel** and will retain their magnetism.

80–10 LODE STONE or NATURAL MAGNET. As suggested by the name, this magnet is a selected piece of iron ore having magnetic properties. It exerts attractive and repulsive force and is readily affected by the earth's magnetic power **$0.40**

80–11 DEMONSTRATION TABLE LODE STONE or NATURAL MAGNET, Same quality as above, but larger in size . . . . . **.80**

80–14 SUPPORTING STIRRUP FOR LODE STONE, used in illustrating the action of the earth's magnetic force. This stirrup will contain either of the lode stones listed above . . . . . **.65**

Nos. 80–10 to 80–11



HORSESHOE MAGNETS WITH KEEPERS

Numbers	80–20	80–22	80–24	80–26	80–28
Length, inches	2	3	4	6	8
Each	$0.08	0.11	0.18	0.48	1.00

80–30 HORSESHOE MAGNET, special design, 2 inches between poles. Length 5½ inches, poles ¾ × ½ inch **$0.35**

80–35 COMPOUND HORSESHOE MAGNET, demonstrating the intensified magnetic force derived by the combination of more than a single magnet **1.70**

80–37 EIGHT-INCH COMPOUND HORSESHOE MAGNET, consisting of four eight-inch single magnets firmly clamped together. With keeper **6.40**

BAR MAGNETS, finest quality steel, excellent retentive quality, neatly polished.

Numbers	80–55	80–57	80–59	80–61
Size, inches	2 × ¼ × ¼	6 × ½ × ¼	8 × ½ × ¼	12 × 1 × ¼
Price . . Each,	$0.18	0.20	0.30	0.60
Per Doz.	1.50			

80–70 BAR MAGNETS, consisting of a pair of 6-inch Bar Magnets in neat wooden box, with keepers . . **.50**

80–80 ROUND BAR MAGNET, excellent quality polished steel, length 6 inches, diameter ⅜ inch . . . . **.25**

80–85 BREAKING MAGNET, illustrating the fact that both polarities of magnetism are present at all parts of the bar, and are not merely at the ends.
This Magnet is 6 inches long by ¼ inch square, weakened at various points to facilitate in the breaking **.22**

80–87 GLASS TUBE and STEEL FILINGS, illustrating the molecular character of magnetism.
This consists of a small glass tube filled with washed steel filings. If the filings are magnetized by the approach of a bar magnet, each small filing will attain the characteristics of a magnet, attracting and repelling adjacent filings, so that they will all cluster together to form a solid mass. This condition may be destroyed by violently shaking the tube, thus destroying the magnetism . . . . . **.50**

80–90 MAGNETIZED STEEL DISC, useful in destroying the conception of the students that magnets must be in the form of rods or bars.
This disc is 2 inches in diameter and has two distinct magnetic poles . . . . . **.55**

80–100 **HARDENED STEEL RODS (KNITTING NEEDLES),** about 1/16 inch diameter by 8 inches long.
These steel rods are useful in the study of Breaking Magnets. Per set of four **$0.10**

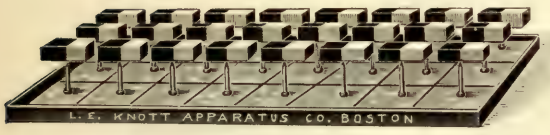
80–105 **SOFT IRON BAR,** for illustrating the action of the earth on magnetic substances; may be used also to illustrate the formation of magnets by enclosing in a solenoid through which passes a current of electricity.
This bar is of the best quality of soft Norway iron and measures 6 × ½ × ¼ . . . . . **.20**

80–106 **SOFT NORWAY IRON ROD,** 20 inches long by ½ inch diameter, for studying the action of the earth on magnetic substances. When this bar is held in the magnetic meridian parallel to the inclination, feeble magnetic polarity is at once noticeable in the bar, the lower extremity being the North Pole as may be demonstrated by testing with a small magnetic needle. This magnetism is unstable, as may be demonstrated by inverting the bar. The magnetic polarity, however, may be made somewhat more stable by imparting to the bar a certain amount of coercive force by giving it several sharp blows with a hammer. This coercive force is, of course, very small, and after a time the magnetism entirely disappears . . . . . **.40**

80–110 **NICKEL STRIP,** for illustrating that other substances than iron have magnetic properties.
This strip is 4 × ¼ inch . . . . . **.30**

80–115 **MAGNETIC SCREENS,** for illustrating magnetic transparency, consisting of a set of six screens of different substances, some para-magnetic, others dia-magnetic . . . . . Per set of six **.70**

80–120 **MAGNET STIRRUP,** for the study of magnetic action in a suspended bar magnet.
This consists of a wire stirrup with a device for holding magnets and also for attaching to a support by a string . . . . . **.10**



No. 80–150

No. 80–160

80–150 **MOLECULAR MAGNET MODEL,** for explaining the distribution of Magnetism in magnetic rods.
This apparatus consists of twenty-four small magnets about 2 centimeters long, each supported on a point and all placed as illustrated, on an insulated board. These magnets will arrange themselves so that the like poles all point in one direction. If, however, the pole of a strong Bar Magnet be presented to one end, the needles will be immediately deflected.
Set of twenty-four, mounted as illustrated . . . . . Duty Free **$9.25**

80–155 **FLOATING MAGNETS,** for illustrating the attraction and repulsion of magnetic poles.
This apparatus consists of a set of six small magnets each on an individual mount that will float in water . . . . . Per set of six **.25**

LINES OF FORCE APPARATUS

80–160 **SUPPORTING BOARD,** for use with a magnet and tracing paper for forming a tracing of the lines of force of a magnet.
This board, as shown in the illustration, has a groove in the middle into which the magnet is placed, bringing the surface of the magnet flush with the top of the board.
In use, a sheet of blueprint paper is pinned to the board over the magnet. Iron filings, sifted over this sheet, will arrange themselves in the lines of force of the magnet . . . . . **.40**

80–165 **MAGNET SUPPORTS.** These supports consist of short strips of wood ¼ inch cross-section. They are designed for use with magnets No. **80–55.** The blueprint paper is placed on these wooden supports . . . . . Per Pair **.08**

80–170 **GLASS PLATES** (6 × 6 inches), for use in mapping out magnetic fields of force.
These plates may be used to advantage with No. **80–165 Supporting Strips,** and No. **80–55 Bar Magnet** . . . . . Each **.10**

80–180 **IRON FILINGS,** for mapping magnetic lines of force. Selected, fine, soft iron filings.
Per ¼ lb. carton **$0.10**
Per lb. in bulk **.20**

80–185 **FILINGS SIFTER,** for evenly distributing filings over a tracing surface . . . . . **.15**

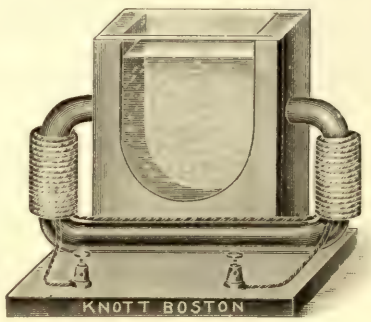
80–195 **BLUEPRINT PAPER,** for permanently recording a magnetic field of force of a bar magnet, as indicated by iron filings. Size 4 × 5 inches . . . . . Per light-proof, sealed package of 24 sheets **.22**

80–196 ——, same as above, size 8 × 10 inches . . . . . Per light-proof, sealed package of 24 sheets **.75**

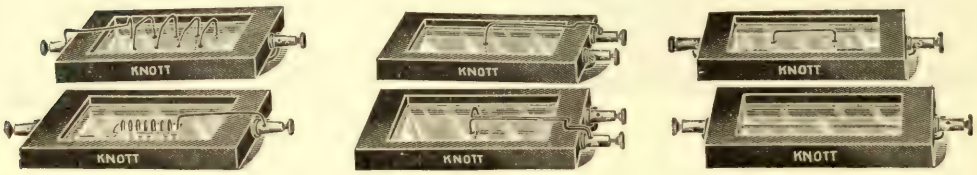
80–198 ——, same as above, but in roll, 30 inches wide, 10 yards long **1.20**

80–200 **DIRECT BLACKPRINT PAPER,** more desirable than blueprint paper as it gives a black line on white ground.
This paper is treated like ordinary blueprint paper, except that the print should be left in the bath from 10 to 15 minutes. . . . . Per 10 yard roll, medium weight, 30 inches wide **2.75**

80–225 **LINES OF FORCE APPARATUS** after Toepler, for showing the magnetic curves between the poles of an electro-magnet. Excellent in projection work.
This apparatus consists of a glass trough placed between the poles of an electro-magnet. This trough, in use, is filled with glycerine in which fine iron filings have been previously mixed. When a current is allowed to pass through the electro-magnet, the small particles of iron will arrange themselves in magnetic curves. This instrument forms an instructive and interesting piece of apparatus . . . . Duty Free **$7.80**

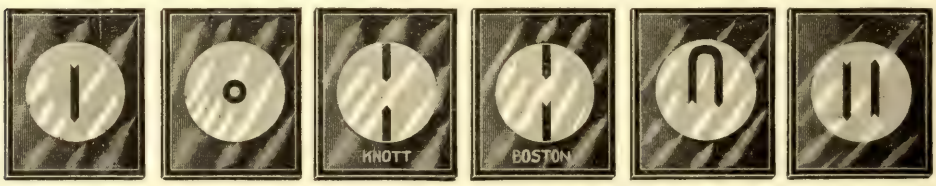


No. 80–225



No. 80–230

80–230 **MAGNETIC LINES OF FORCE APPARATUS,** for use with a Vertical Projector in showing on a screen the lines of force about a current.
This apparatus consists of a set of six slides, each slide being a glass plate set in a wooden frame. Through holes bored in the glass, various forms of wire are set. In projection work, this set will be found invaluable . . . . . Per set of six slides **$13.50**

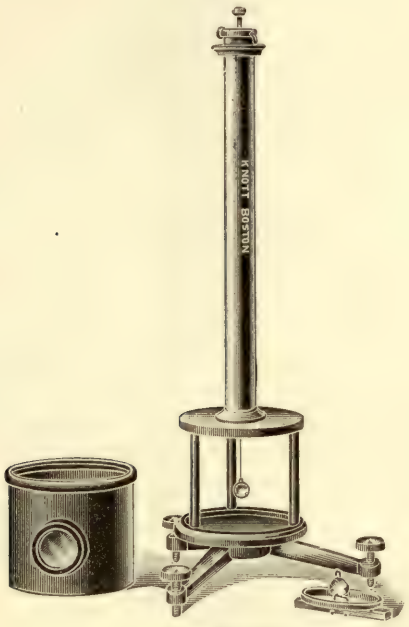


No. 80–232

80–232 **MAGNETIC LINES OF FORCE APPARATUS,** for use with a Vertical Projector in showing on a screen the lines of force about a magnet.
This apparatus, similar to Set No. **80–230,** consists of a set of six slides, each slide consisting of two plates between which are placed thin steel magnets of various forms and differently arranged as illustrated . . . . . Per set of six slides **$8.50**

80–235 **MAGNETIC LINES OF FORCE SLIDES,** for illustrating on a screen the fields of force shown by iron filings.
These slides are direct photographs and are selected from our Miller Collection. The set consists of five slides illustrating the field of: (1) **Single Bar Magnet;** (2) **Two Bar Magnets, Unlike Poles;** (3) **Two Bar Magnets, like Poles;** (4) **Two Bar Magnets at Right Angles;** (5) **Ring Magnets.**
Per set of five **2.00**

MAGNETOMETERS



No. 80–255

80–250 MAGNETOMETER, after Millikan & Mills' "Electricity, Sound and Light," Experiment 2, for determining the magnetic moment (M) and horizontal component of the earth's magnetic field (H), by first determining the relations M/H and MH.

This magnetometer, capable of exact work, consists of a brass housing, polished lacquer and gun metal finish, mounted on a japanned tripod, provided with leveling screws. This housing is free to turn about a vertical axis and may readily be removed without disturbing the suspended system. The suspension system consists of a plane mirror to the back of which are cemented five small magnets. This system is held by a silk fiber suspended from a graduated torsion head.

Complete with Magnet System and Silk Fiber Suspension **$18.00**

80–251 BAR MAGNET AND METER ROD SUPPORTS. In determining the value M/H a bar magnet of a size determined by the diameter of the lower part of the housing and an appropriate support for the same, east and west of the suspended system, is needed. Our design utilizes the standard meter rod found in every laboratory. The rod is supported by a pair of improved supports. The magnet is supported in a clip which may be attached to the meter stick wherever desired. This holder is supplied with an index for reading its position on the rod.

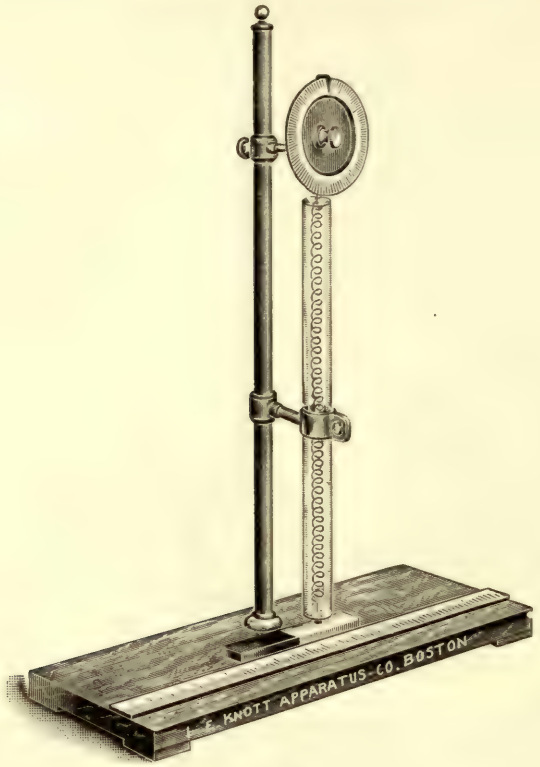
A pair of Meter Rod Supports, Magnet Holder with Index and Special Magnet **2.25**

80–253 INERTIA ACCESSORIES, for use with above Magnetometer, in determining the moment of inertia of the magnet of No. **80–251**.

This system consists of a stirrup to which is attached a plane mirror and which is designed to hold the magnet. That results may be checked, a brass inertia ring is supplied.

Inertia Ring, Magnet, and Stirrup with Attached Mirror **4.00**

80–255 MAGNETOMETER and ACCESSORIES. For the convenience of those who desire to purchase a combination necessary to determine the relation M/H and MH we list under this number, the **Complete Magnetometer** and **Accessories** needed, including No. **80–250** Magnetometer and Suspended System, No. **80–251** pair of Meter Rod Supports, Magnet Holder with Index and Special Magnet, and Stirrup with Attached Mirror and Inertia Ring of No. **80–253**. Complete **24.25**



No. 80–265

80–265 **SPRING MAGNETOMETER,** after Stewart & Gee's " Elementary Practical Physics," Lesson XIII, for determining the distribution of magnetism along a bar magnet.

This magnetometer comprises a graduated silvered metal dial attached to the upright and fitted with a pulley to which a silk cord with attached spiral spring is fixed. This silk cord passes around the pulley which is mounted in a friction collar. At the end of the spiral spring is fixed a piece of soft iron to insure that the pull from the magnet is vertical. The spiral spring works within a glass guard tube. The graduated dial is supported by an arm and can be raised or lowered at will. The whole is mounted on a polished mahogany base with graduated rod.

In use, the zero point is obtained by substituting for the magnet a piece of wood of the same dimensions, then turning the milled head until the soft iron piece just touches the surface of the wood. Place the magnet in position, and determine the number of divisions through which the milled head must be turned, to detach the iron piece. Readings should always be made from the middle of the magnet toward each end. From a number of such readings, it will be noted that the magnetic strength is directly proportional to the distance from the center.

Complete with Special Magnet and similar wooden strip . . . . . Duty Free **$7.50**

No. 80–270

80–270 **DEFLECTION MAGNETOMETER,** for comparing the strength of the poles of a bar magnet.

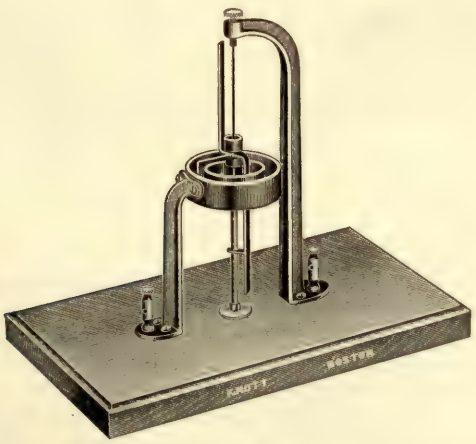
The apparatus consists of a polished mahogany base board to the surface of which is fastened a meter rod. Midway between the ends of this rod a delicate magnetic needle is placed, with the 50 centimeter division of the rod directly under the supporting pivot of the needle.

Complete with Magnetic Needle and Bar Magnet **$4.00**

No. 80–280

80–280 MAGNETOSCOPE, after Chute's "Physical Laboratory Manual," Problems 104 to 106, for measuring relative magnetic transparencies of various substances; for comparing strength of poles and determining distribution of magnetism along a bar magnet.

This simple instrument, capable of relatively exact measurements, consists of a heavy jar of special design, mounted on a wooden pedestal. A strongly magnetized permanent magnet is suspended through a stopper plug **$1.25**



No. 80–300

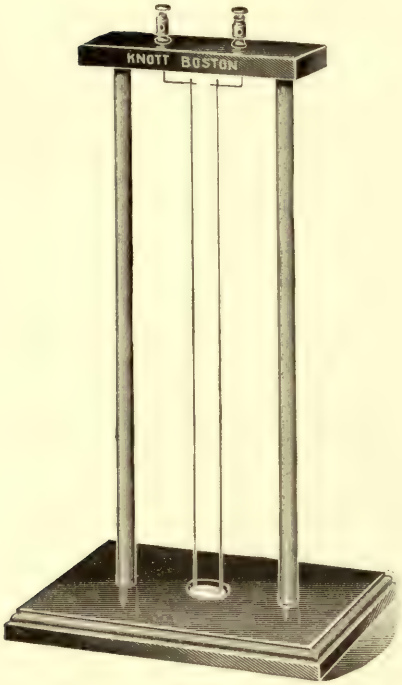
80–300 MAGNETIC POLE ROTATION APPARATUS, for demonstrating the tendency of a current and a magnet pole to rotate about each other.

The apparatus consists of a jewel-mounted magnet supported so that the current passes along half the length of the magnet and is carried away at the middle. The magnet is supported at its center on a fine point on top of a post. The current is brought to a mercury cup fitted to the magnet, and a bent copper wire attached to this cup dips into an annular mercury cup, whence it is carried away by the upright support to which the cup is attached. When a strong current is passing (3½ amperes at 7 volts pressure, at least) one pole will rotate steadily. By reversing the direction of the current, the direction of the rotation is reversed.

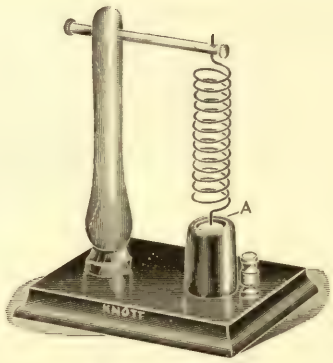
Complete as illustrated **$5.50**

80–115 MAGNETIC SCREENS, set of six screens of different substances, some para-magnetic, others diamagnetic . . . . . **.70**

PARALLEL CURRENT APPARATUS



No. 80–305



No. 80–310

80–305 PARALLEL CURRENT APPARATUS, for illustrating mutual actions of parallel currents. The design consists of an insulated stand to the head of which are attached binding posts in electrical connection with two bent copper wires. To these bent wires are suspended two straight copper rods cut to lengths that will allow their free ends to extend within the mercury well set in the base.

In use it is always best to amalgamate the ends of these copper rods. Success of the experiment depends also upon allowing the rods to just make contact with the surface of the mercury. Parallel currents flowing in the same direction may be secured by connecting both binding posts with one pole of the battery; the other pole should be connected to a binding post (not shown in illustration) fastened to the base and in electrical connection with the mercury well.

Parallel currents running in opposite directions may be obtained by simply connecting the battery terminals and the binding posts, at the top.

In the first case, repulsion of the wires will be noted; in the second attraction **$1.70**

80–310 VIBRATING SPIRAL APPARATUS, for illustrating mutual action of parallel currents.

The apparatus consists of a stand with upright. In the base is set a mercury well in electrical connection with a binding post. A horizontal rod set into the upright near the top is provided at one end with a binding post and at the other with a binding screw, the latter designed to support one end of a loose copper wire spiral. The other end of this spiral extends within the mercury well. In use, this end should be regulated to just touch the surface of the mercury. When a current is allowed to pass through the spiral, there is an attraction between the convolutions, causing the lower end of the spiral to break the electrical connection with the mercury. The weight of the spiral then causes contact again, which, in turn, sets up attraction of the convolutions. Continual making and breaking contact with the mercury causes this spiral to vibrate up and down **2.15**

MAGNETIC DISTRIBUTION APPARATUS

No. 80–325

80–325 MAGNETIC DISTRIBUTION APPARATUS, after Stewart & Gee's " Elementary Practical Physics," Lesson LXXII, for studying the distribution of magnetism along a soft iron bar magnetized by induced currents from a magnetizing helix.

This apparatus consists of a long, soft, Norway iron bar, mounted on supports as illustrated. At the end are two short pieces of brass of the same diameter as the iron rod, permitting the whole length of the iron rod to be brought under experimentation. For magnetizing purposes a test coil which may be clamped to any part of the bar, is supplied. A small reel wound with fine wire is employed as the induction coil. The range of play and the position of the test coil is determined by two brass guides between which this reel is placed. The guide and reel are each provided with screws for clamping to the rod.

Complete as illustrated **$12.50**

No. 80–330

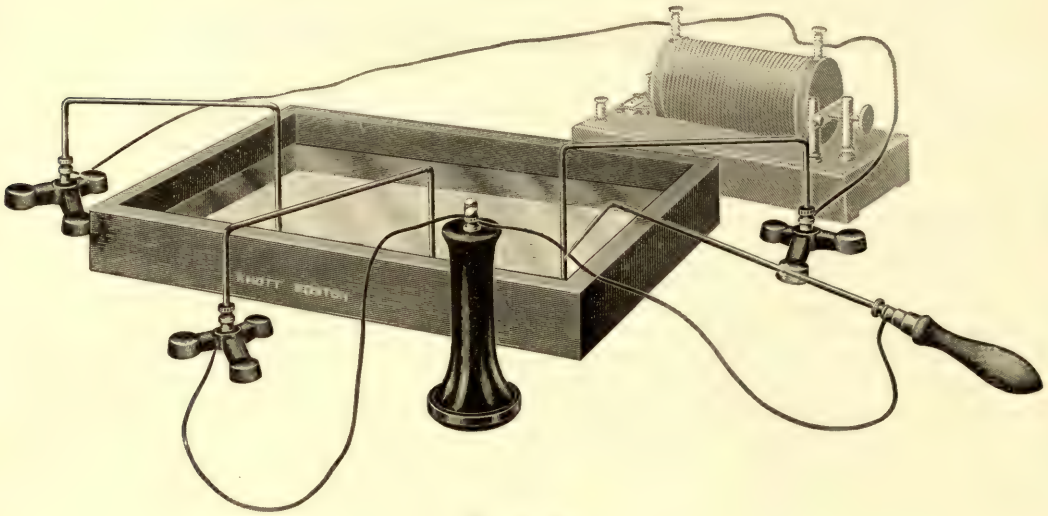
80–330 ROWLAND'S DISTRIBUTION OF MAGNETISM APPARATUS, after Millikan & Mills' " Electricity, Sound, and Light," page 137.

This apparatus consists of a bar magnet enclosed in a brass tube. A small " test coil " fits closely over this tube and may be adjusted along the same and clamped in any position desired. The range of play and position on the tube is determined by two brass guides between which this test coil is placed. The guides and reel are each provided with screws for clamping to the tube. To facilitate in adjustment, this tube is mounted as illustrated.

In use, the terminals of the test coil are connected to the moving coil galvanometer, the deflections of which will be proportional to the quantity of induced electricity which flows through the galvanometer, and hence to the number of lines entering or leaving the magnet in the space over which the coil is moved.

Without support **$9.75**

EQUIPOTENTIAL APPARATUS



No. 80–350

80–350 EQUIPOTENTIAL DETERMINATION APPARATUS, after Millikan & Mills' " Electricity, Sound, and Light," Experiment 1, for mapping the equipotential surface of an electrical field and drawing the force lines.

The apparatus consists of a field tray with glass bottom, through which may be seen a sheet of co-ordinate paper. This tray is an improved design by C. H. Andrews, South High School, Worcester, Mass. With this design it is impossible for the salt solution to come into contact with the paper, and the whole tray may be thoroughly cleaned without removing the glass plate. It has the further advantage, also, of facilitating the replacing of broken plates. Three bent wires, each with weighted support and binding post, are provided. Two of these are maintained at points of different potentials and about which it is desired to find equal potential lines which lie in one plane. A constantly varying potential difference is secured by connecting these points to the secondary of an induction coil. A fourth bent point with insulating handle and binding post is used with the third point as illustrated in locating the points of equipotential. The fourth point may then be considered the equipotential seeker.

In use, the bottom of the tray is covered with a solution of ammonium chloride or any convenient salt. The bent wires then are located as illustrated, two connected to the secondary of an induction coil the primary of which is connected to a dry cell, the third and the equipotential seeker are connected to telephone receiver. By adjusting the position of the third wire to various points in the plane of the liquid, points of equipotential for these different points may be located by means of the seeker. These points will be found when there is no " buzzing " in the telephone receiver. Results may be transferred to a sheet of co-ordinate paper and equipotential lines and the lines of flow drawn.

Complete apparatus consists of the Field Tray and the four bent wires, three with weighted supports and binding posts, the fourth with insulating handle. Complete **$6.00**

80–351 FIELD TRAY, improved design by Andrews **4.00**

80–352 BENT WIRE, WITH WEIGHTED SUPPORT AND BINDING POST . . . . . Each **.50**

80–353 BENT WIRE, WITH INSULATING HANDLE AND BINDING POST . . . . . Each **.50**

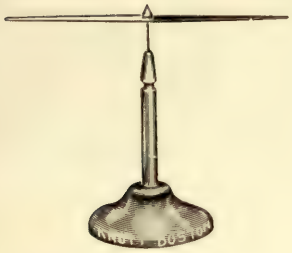
19–67 CO–ORDINATE PAPER, ruled 6 × 8 inches on sheet 8½ × 10½, millimeter ruling, heavy centimeter divisions . . . . . Per 100 sheets **.50**

80–355 INDUCTION COIL, small size with modified hammer, especially adapted to this work **4.00**

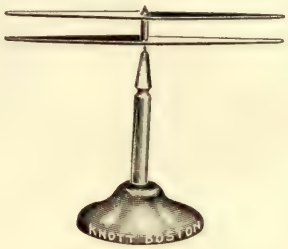
80–360 BIPOLAR DISSECTIBLE TELEPHONE RECEIVER, as above illustrated **1.75**

TERRESTRIAL MAGNETISM

MAGNETIC NEEDLES



No. 81–10



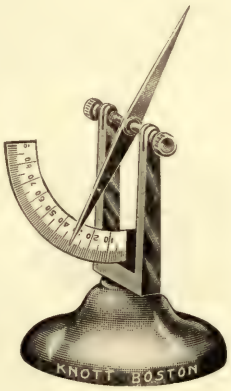
No. 81–15

81–10 **MAGNETIC NEEDLE,** brass capped, agate bearing, neat stand with pinion, needle 6 inches long . . **$1.25**

81–12 ——, same as above, brass capped only . . . . . **.60**

81–15 **ASTATIC NEEDLE,** improved design, brass caps, neat stand with pinion, needle 6 inches long, system mounted so that like or unlike poles may be opposite each other **2.00**

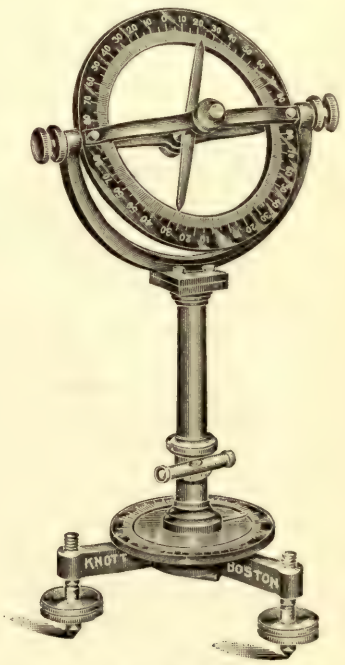
No. 81–50



No. 81–55

81–50 **STUDENTS' DEMONSTRATION DIP NEEDLE,** as designed by W. R. Pyle of Morris High School, New York City.

This instrument consists of a stand on which may be supported the dipping system. It is intended that this system should be magnetized by the student. For this purpose, there are supplied four steel rods 1/16 inch diameter, about 8 inches long. Our dipping system consists of a device whereby one of these steel rods may be mounted and balanced unmagnetized and clamped in the system. The needle is then magnetized by stroking from the middle toward each end with a strong bar magnet. The dip, then, may be taken and noted. This little instrument has found ready favor in many schools and is highly recommended for its didactic features **$2.00**



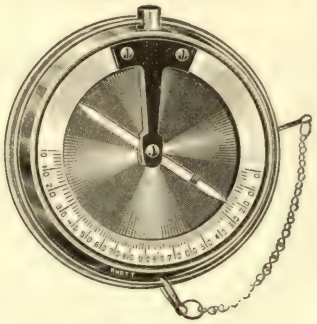
No. 81–60

81–55 **DIPPING NEEDLE,** for showing magnetic dip.

This design consists of a standard on which is mounted a forked casting. In this forked casting is mounted, in pivotal bearings, a carefully magnetized and balanced needle. A graduated arc, also mounted in this forked casting, gives the magnetic dip **$3.30**

81–60 **DIP NEEDLE.** This instrument, of the highest quality, and capable of exact determinations, consists of a horizontal circle mounted on a tripod with leveling screws. Above the circle is a pillar movable about a vertical axis and ending above in a forked stirrup, designed to support the dip system. This system consists of a silvered-metal engine-divided circle fitted between brass stirrups which act as a support for the needle. Set screws fitted with cones and lock nuts carry the hardened steel axes of a delicately balanced needle. The sensitive spirit level mounted on the pillar facilitates leveling . . . . . Duty Free **16.50**

COMPASSES



No. 49–27

49–27 MINER'S COMPASS or DIPPING NEEDLE, a serviceable guide to the location of magnetic iron ore.

In this instrument the magnetic needle is horizontally balanced on an axis within a graduated circle and in which the needle will be found to assume a position inclined to the horizon. When used for tracing ore, the observer should hold the ring in his hand and keep the needle north and south, standing with his face to the west. The inclination of the needle as read off on the graduated scale will show the dip. If the compass is held horizontally, it serves as an ordinary compass. This compass is handsomely finished with raised silvered-metal graduated scale, and is 3½ inches in diameter. It is provided with a brass cap cover and is enclosed in a neat plush-lined box **$11.00**

Nos. 81–76 to 81–78

Nos. 81–85 to 81–87

No. 81–95

81–75 MAGNETIC COMPASS, consisting of small delicately balanced needle mounted in polished brass case, with card dial, diameter 12 millimeters . . . . . Per Dozen **$1.40**

81–76 MAGNETIC COMPASS, similar to above, but 25 millimeters diameter, and supplied with ring . . **.18**

81–77 ——, same as above, but 35 millimeters diameter . . . . . **.25**

81–78 ——, same as above, but 50 millimeters diameter . . . . . **.33**

81–85 MAGNETIC COMPASS, superior quality, raised metal dial with full circle divisions, delicately balanced needle with brass-capped agate bearing enclosed in polished brass case, with stop for needle, diameter 30 millimeters **$1.05**

81–87 ——, same as above, but 50 millimeters diameter **1.30**

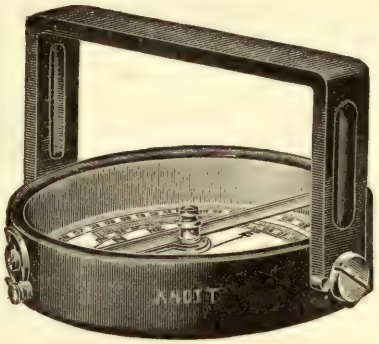
81–95 MAGNETIC COMPASS, raised metal dial, with full circle divisions, agate cap needle, with 37-millimeter aluminum pointer, enclosed in polished brass case, with stop for needle, diameter 50 millimeters **1.65**

81–100 MAGNETIC POCKET COMPASS, card dial, full circle divisions with cardinal points, needle with brass-capped bearing with stop, inside a polished mahogany box with hinged cover, diameter 2½ inches **1.25**

81–101 ——, similar to above, but silvered-dial and raised ring, needle with brass-capped agate bearing **3.00**

No. 81–100

No. 81–125



No. 81–130

81–125 WATCH CASE SIGHT COMPASS, 2¼ inches in diameter, excellent quality with full circle divisions on raised dial. Nicely balanced needle, 1¼ inches long, with agate bearing. Provided with folding sights. Spring cover **$6.60**

81–130 BRIDGE SIGHT CLINOMETER COMPASS, for use both as a clinometer and as a sight compass. This useful instrument is constructed to fulfill the office of both clinometer and sight compass. The sights are made in the form of a bridge and can be turned on their pivots at right angles.

The needle of this compass is a hardened and tempered edge bar with needle jeweled center. It is mounted within a three-inch bronze case provided with a silvered-metal dial **7.50**

No. 81–140

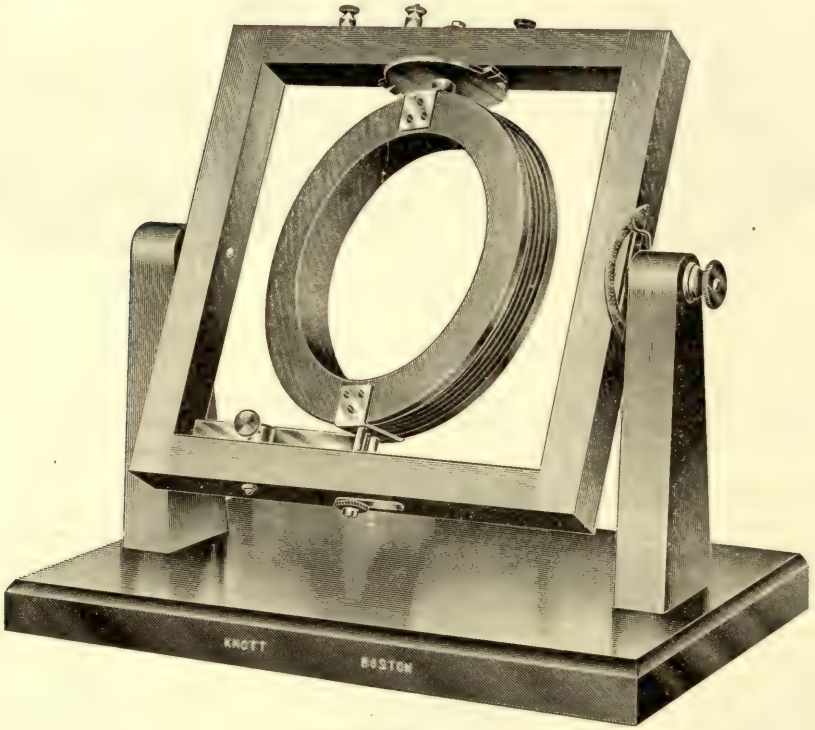
81-140 MARINE COMPASS, — a compass in which the moving system is floated in alcohol.

This is a high-grade instrument 5 inches in diameter. The moving system floating in alcohol is contained in a compensating chamber. It has a standard marine compass dial with line sights. The instrument is furnished in a neat mahogany case **$11.50**

49–25 SUN DIAL AND COMPASS. This little instrument, 2 inches in diameter, combines features of both compass and sun dial. It is a pocket compass with raised dial with distinct divisions and figures, and agate center needle. As a sun dial, it is provided with distinct hour lines and may be readily set to any latitude. Case is nickel-plated and provided with hinged cover. Duty Free **$6.75**

No. 49–25

UNIVERSAL INCLINATION EARTH INDUCTOR



No. 81–155

81–155 UNIVERSAL INCLINATION EARTH INDUCTOR, for exact study of the magnetic moment of the earth's pole.

This improved design consists of a substantial base with uprights to which is swiveled a frame carrying a ring. The frame carrying the coil may be inclined to any angle within 180 degrees, the inclination being indicated by a pointer moving before a graduated arc. The ring has a groove in which are coiled about 1000 turns double silk-covered wire. The leads of this wire are heavily insulated and the ends brought to binding posts shown on top of the frame. A positive throw is secured by a simple spring device shown at the bottom of the frame. This device, when set for use, is held by a projecting rod acting against the spring giving to it a tension. A release and stopping device, actuated by one button, gives to the ring a definite rotation through 180 degrees. This inductor is carefully made and must not be confused with those at a lower price on the market. Our mounting is of the most substantial construction, well finished, making the instrument not only of scientific value, but one in which any laboratory will take pride.

FEATURES:

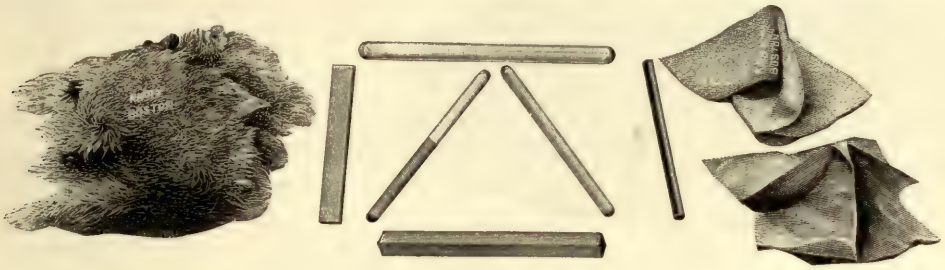
1. Universal inclination in two planes.
2. Gimbal mounting for varying the angle of inclination.
3. Graduated arc and pointer for easily determining the same.
4. Positive spring device for securing a definite rotation through 180 degrees.
5. A release and stopping device actuated by one button.

To facilitate in determining the constant of the instrument the B. & S. Gauge No. of wire, the inner and outer diameter of the coil, the number of turns in the coil and the resistance are all permanently recorded on the instrument **$22.00**

GENERATION OF STATIC ELECTRICITY

FRICTIONAL ELECTRICITY ACCESSORIES

In listing our line of Frictional Electricity Accessories, we desire to state that we use only the purest materials which, from our experimentation, have proved most satisfactory. Results, therefore, are assured.



Nos. 82–10 to 82–65

82–10 **AMBER SPECIMEN,** illustrating the power of amber in attracting light bodies, when rubbed with silk **$0.95**

82–15 **FRICTION ROD OF GLASS,** developing a positive charge when rubbed with silk, negative when rubbed with catskin or flannel . . . . . **.18**

82–20 **GLASS FRICTION ROD,** one-half ground, other half polished, developing both positive and negative charges regardless of the "rubber" . . . . . **.55**

82–25 **VULCANITE FRICTION ROD,** developing a negative charge when rubbed by catskin, flannel, or silk . . . . . **.42**

82–30 **WAX FRICTION ROD** (Sealing wax), developing a negative charge when rubbed by catskin, flannel, or silk . . . . . **.10**

82–35 **CELLULOID STRIP,** 12 inches long, developing a negative charge when rubbed by catskin, flannel, or silk . . . . . **.18**

82–40 **FRICTION ROD, HALF GLASS, HALF BRASS,** illustrating rapid conduction of charge from a conductor . . . . . **.75**

82–50 **SILK EXCITING PAD** . . . . . **.40**

82–55 **FLANNEL EXCITING PAD** . . . . . **.25**

82–60 **CATSKIN,** small size, **whole skin** . . . . . **.75**

82–65 **CATSKIN,** large size, **whole skin** **1.25**

No. 82–75

82–75 **CHARGING ROD.** This charging rod has been designed in order to provide a simple and certain means for charging electroscopes. The charges are produced by the friction between a piece of flannel and a resinous rod. The whole is surrounded by a brass case which acts as a guide for the movable flannel ring. The rod can be used to produce either positive or negative charges **$6.50**

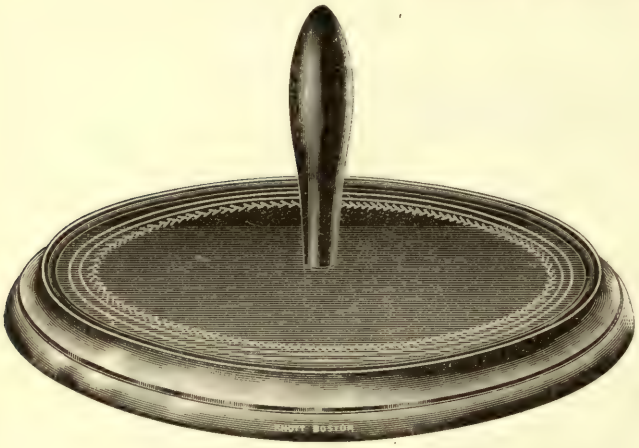
82–95 **RUBBER GLOVES,** for exciting Friction Rods.

For women, sizes 6 to 9 . . . . . Per Pair **2.50**

For men, sizes 8 to 10 . . . . . Per Pair **2.50**

No. 82–95

ELECTROPHORUS

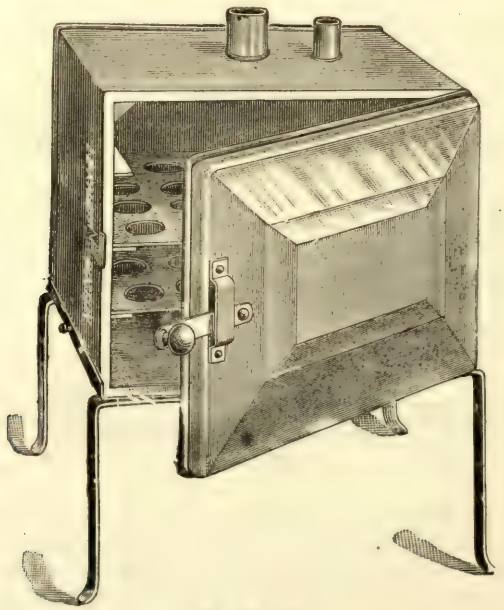


No. 82–110

No. 82–115

82–110 RITCHIE'S LECTURE TABLE ELECTROPHORUS, for generation of static charges by the principle of influence. The plate of this electrophorus is 12 inches in diameter, constructed of a special high quality electro-static rubber mounted in a finished metal base. The disc is of heavy brass finely finished, provided with an insulating handle. It is handsomely finished throughout and built on a large plan so that it may be used to advantage on the lecture table **$9.25**

82–115 CAST-BASE ELECTROPHORUS. In this instrument, above illustrated, we secure a fine-quality instrument capable of striking results. The plate consists of a shallow trough casting in which is moulded a cake of resinous material. The disc is of heavy brass, provided with an insulating handle **2.95**



No. 82–125

82–125 DRYING OVEN. The success of frictional experiments depends largely upon the condition of the accessories. All accessories should be as dry as possible.

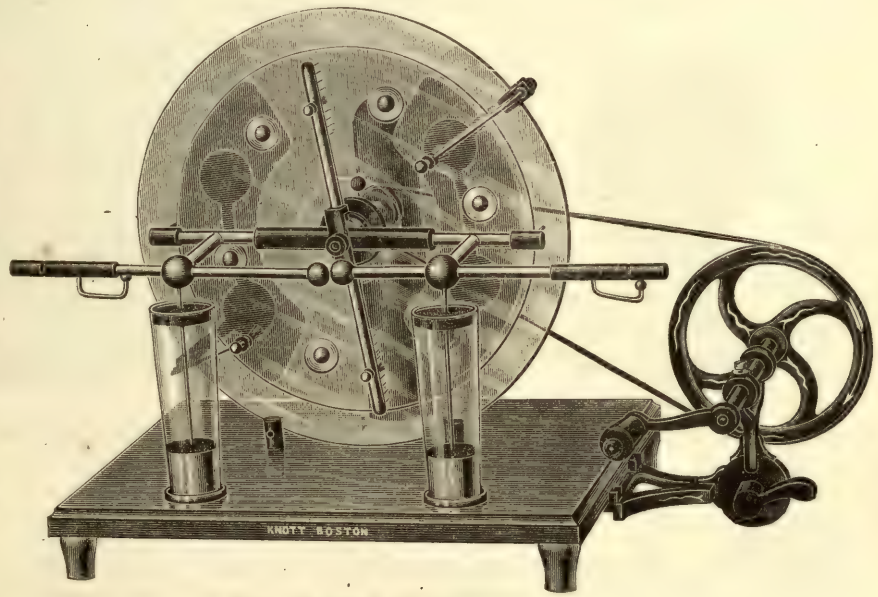
This drying oven is made of polished copper, single wall with extra sheet iron bottom, tubulations for thermometer and gas regulator, one removable shelf. Inside measurement, 8 × 10 inches . **$6.00**

INFLUENCE MACHINES

We furnish the two standard types of Influence Machines, the Toepler-Holtz (single rotation) and the Wimshurst (double rotation.) The design of each is a matter of utmost importance. We strive to secure the maximum efficiency for plates of the sizes listed. To secure this, parts must be well proportioned and material used in construction well chosen. By careful attention, therefore, to essential details we are enabled to secure an efficiency and a design excelled by none. All parts are carefully finished and the construction is simplified so that even the least mechanical may readily assemble the parts when once received. Under normal conditions either type is guaranteed to furnish a spark length of about one-third the diameter of the revolving plate. In both types no change of poles is necessary, as the changing is secured by the construction of the machine itself.

TOEPLER-HOLTZ INFLUENCE MACHINES

In the machines of this type, we have greatly improved the insulation of parts, thereby greatly diminishing the leakage of charges. We claim a superiority of the following essential features:



Nos. 82–150 to 82–170

GLASS PLATES. The plates furnished on our machines are constructed of a special quality of toughened glass, thus greatly obviating frequent breakages. The varnished coating is of a special recipe applied by an improved process which gives to the plates a durable and hard but smooth surface.

CONSTRUCTION. All parts of this machine are carefully fitted and neatly finished. Material selected is of the best. The machine is carefully constructed and tested. In shipping it is necessary to send "knocked down." As construction is as simple as possible, all parts may be readily assembled.

MOUNTING. The pillar and base are of polished mahogany, the driving parts of metal, and the drive wheel provided with small but efficient belt-tightening device.

CONDENSERS. Leyden Jars are used as condensers. These jars are constructed as large as practicable for each size machine. Glass used is of special quality, especially adapted for condenser work.

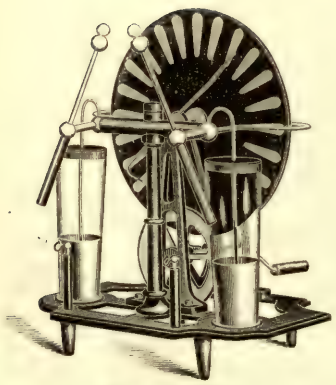
82–150 THREE-PLATE TOEPLER-HOLTZ MACHINE, one fixed and two revolving glass plates, diameter of revolving plates 10 inches, fixed plate 12 inches, guaranteed spark length about 3 inches.
From Stock **$19.50**

82–160 THREE-PLATE TOEPLER-HOLTZ MACHINE, one fixed and two revolving glass plates, diameter of revolving plates 12 inches, fixed plate 14 inches, guaranteed spark length about 4 inches.
Duty Free **21.00**

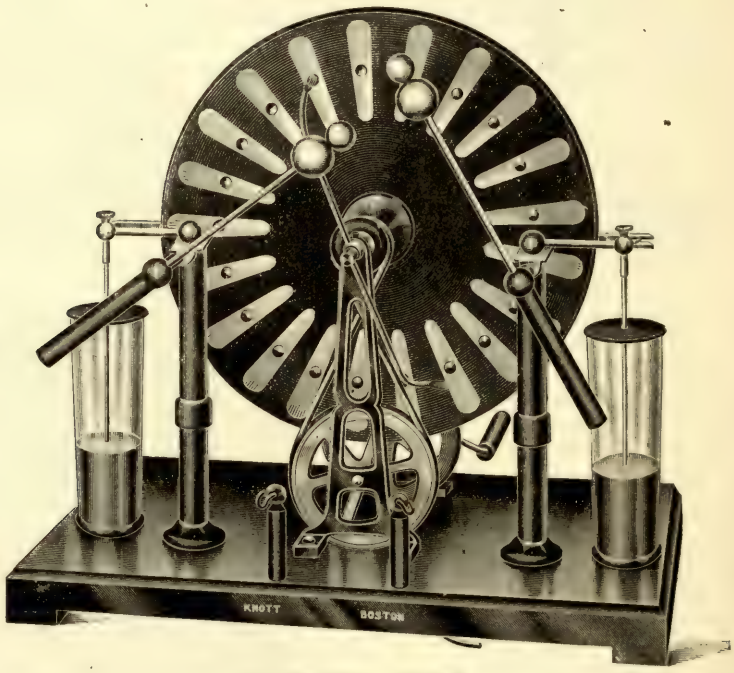
82–170 THREE-PLATE TOEPLER-HOLTZ MACHINE, one fixed and two revolving glass plates, diameter of revolving plates 14½ inches, fixed plate 16½ inches, guaranteed spark length about 5 inches.
Duty Free **35.50**

WIMSHURST MACHINES

EBONITE — PLATES — GLASS



Nos. 82–190



No. 82–195 to 82–205

This type of machine is highly recommended as an economical machine of high efficiency. In our machines only the best quality of European ebonite is used. By actual test it may be demonstrated that with this quality a machine will prove much more efficient and longer lived than those constructed of the American hard rubber. Our plates are practically indestructible and if kept from direct heat rays, are guaranteed not to warp.

All parts of this machine receive the same careful attention as is given to the manufacture of our Toepler-Holtz type. We strive to furnish a high-grade instrument at a reasonable price. Only the best of material is used. Parts are proportioned to secure the highest efficiency capable from types listed.

82–190 EBONITE PLATE WIMSHURST INFLUENCE MACHINE, two counter revolving ebonite discs 8 inches diameter, guaranteed spark length about 3 inches . . . . . From Stock **$12.00**

82–195 EBONITE PLATE WIMSHURST INFLUENCE MACHINE, two counter revolving ebonite discs 14 inches diameter, guaranteed spark length about 5 inches . . . . . Duty Free **31.00**

82–200 EBONITE PLATE WIMSHURST INFLUENCE MACHINE, two counter revolving ebonite discs 16 inches diameter, guaranteed spark length about 6 inches . . . . . Duty Free **37.50**

82–205 EBONITE PLATE WIMSHURST INFLUENCE MACHINE, two counter revolving ebonite discs 20 inches diameter, guaranteed spark length about 7 inches . . . . . Duty Free **49.50**

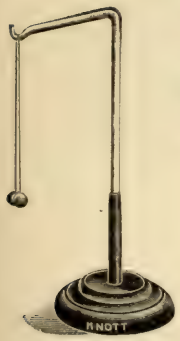
82–210 GLASS PLATE WIMSHURST INFLUENCE MACHINE, two counter revolving glass discs 12 inches diameter, guaranteed spark length about 4 inches . . . . . From Stock **24.00**

STATIC ELECTROMETERS

83–10	**PITH BALLS,** assorted plain and colored	Per Dozen	**$0.25**
83–12	**PITH BALL STATIC ELECTROMETER,** attached to silk cord, ready for use	Each	**.08**
83–15	**METALLIC COATED PITH BALL,** vastly more sensitive than the uncoated	Each	**.12**
83–17	**PITH BALL,** one-inch diameter	Each	**.75**
83–33	**GOLD-LEAF, PURE GOLD,** in book form for electroscope	Per Book	**.75**
83–35	**ALUMINUM-LEAF,** in neat compact roll, especially prepared for electroscope work	Per Roll	**.35**
83–40	**TIN FOIL,** for Leyden Jar coatings, Condensers, etc.	Per Pound	**.60**

No. 83–50

83–50 GILDER'S KNIFE, PAD, AND TIP, for cutting of gold-leaf.
Frequent statements have been made us that it is almost impossible to replace broken leaf on electroscopes. This trouble arises, principally, from lack of proper tools. The outfit illustrated above will facilitate in the cutting and handling of even the finest gold-leaf.
Knife, Pad, and Tip, complete **$2.50**



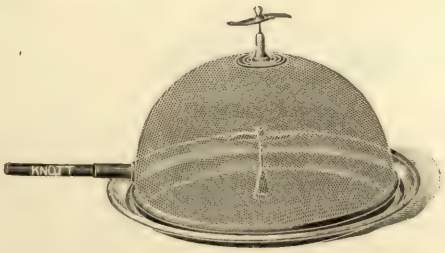
No. 83–75

83–75 PITH BALL ELECTROSCOPE, for qualitative demonstration of static charges.
This apparatus consists of a base on which is mounted an insulated support with arm. To this arm are suspended two pith balls, by fine silk fiber **$0.60**

83–100 PITH BALL ELECTROSCOPE, large size for lecture table demonstration. Two pith balls 1 inch diameter mounted as illustrated in No. **83–75** **3.25**

No. 83–105

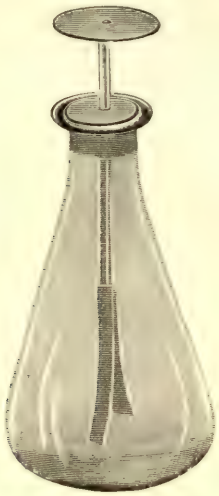
83–105 CHRISTIAN BROTHERS' ELECTROSCOPE. This simple instrument is in many respects superior to the ordinary electroscope. It is extremely sensitive and acts with readiness without the aid of drying agents. If desired, one part of it may be charged negatively and another positively at the same time and indications are readily observed by all members of the class.
It consists of an insulating stand on which is pivoted an ebonite needle of most approved size and shape for sensitive work. The only directions for care is that the needle should be dismounted when not in use and wrapped in brown paper so as to exclude light. By this means the needle is always in good condition. ready for instant use . **.80**



No. 83–110

83–110 HARCOURT ELECTROSCOPE, for demonstrating static charges, also illustrating an electric shield.
This apparatus consists of a metal plate in the center of which is placed a light mounted indicating needle. A metal screen with insulating handle is provided for placing over the plate. A second mounted needle is provided on top of the metal screen.
Upon the approach of a spark from a Static Machine or of any static charge it may be demonstrated that the upper needle is attracted or repelled while the lower remains unaffected **$2.25**

ELECTROSCOPES

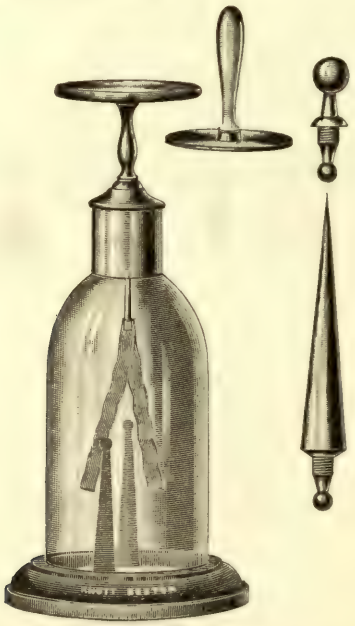


No. 83–135

No. 83–140

83–135 **STUDENTS' ELECTROSCOPE,** simple flask form **$0.66**

83–140 **SIMPLE GOLD LEAF ELECTROSCOPE.** This form is designed for teachers who desire a larger and more substantial electroscope than the one immediately preceding. It is of the form shown in the illustration, with the exception that it is so constructed that the leaves of gold will not touch the sides of the jar when they are extended **1.70**



No. 83–150

83–150 **BENNETT'S GOLD LEAF ELECTROSCOPE WITH VOLTA'S CONDENSING PLATE AND SAUSSURE'S POINT DISCHARGE.** This instrument is intended for sensitive work in testing electrification of a body and in determining the polarity of the same. In our design we use the best quality of electrical glass and further increase the conducting quality of this glass by grounding it. The jar used is of special mould which allows of the use of the various attachments without disturbing the gold leaves. As a **Simple Gold Leaf Electroscope** the knob top alone is used. When it is desired to use the **Volta's Condensing Plates,** this knob is unscrewed and the bottom plate put in its place. Differing from the usual method of securing a condensing surface on these plates, we furnish with each instrument a special dielectric which greatly increases the condensing power. The bottom plate is replaced by the **Saussure Point Discharge** when it is desired to test the effects of points in discharging electricity from the surface of a conductor.

This electroscope is of heavy construction and is handsomely finished throughout. It is furnished complete with interchangeable knob, Volta's Condenser Plates, one with insulating handle, and with Saussure's Point Discharge **$8.75**

THE WILSON RADIO-ELECTROSCOPE

DESIGNED FOR RESEARCH WORK ON RADIO-ACTIVITY

83–165 THE WILSON RADIO-ELECTROSCOPE. This instrument, which was originally manufactured at the request of the Department of Physics of the University of Toronto, instantly met with much favor among all workers in the radio-active field and has for several years been considered standard for high-grade work.

As the illustration shows, the instrument is especially designed for telescope reading, a special telescope with cross-hair mounting having been designed for the exact measurement of the angular movement of the gold leaf. The form is such that it also lends itself perfectly to lantern projection.

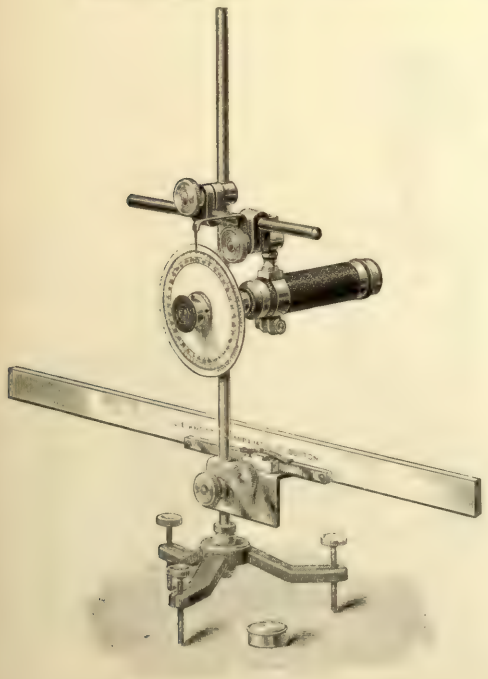
INSULATION. The insulation is as perfect as the purest amber can make it, it having remained charged for 48 hours with no fall capable of being detected with telescope reading.

SELF LEVELING. Owing to the method of supporting the gold leaf member, no care is required in leveling, the gimbal bearing making it perfectly automatic.

METHOD OF USING THE RADIO-ACTIVE MATERIAL. The opening in the base pillar, seen in the illustration, is designed for the ready inserting of the material to be tested. In use, this material is placed in a small watch glass and inserted in the opening, the outside collar then being moved up to exclude all air currents and to keep the conditions within the instrument as nearly uniform as possible. The distance between the radio-active material and the gold leaf is variable and easily determined by the number of discs seen in the illustration, which are placed under the watch glass, thus fixing definitely the distance between the radio-active material and the gold leaf. It will thus be seen that all conditions have been carefully considered and provided for.

Price, complete **$12.00**

No. 83–165



No. 83–170

83–170 MOUNTED TELESCOPE FOR RADIO-ACTIVE WORK. This telescope has been designed for rapid and exact measurement of the angular drop of the gold leaf due to the gradual loss of potential under the influence of the radio-active material. A four-inch aluminum graduated dial is mounted on the eye-piece of a reading telescope in such a manner that the dial, eye-piece and cross-hair move as a rigid unit. The angular movement of the cross-hair is therefore easily read by the dial and pointer.

In use, the eye-piece is rotated until the cross-hair is parallel to the deflected gold leaf. Note the reading on the dial in degrees. After the lapse of a single unit of time, the dial is to be turned again until the cross-hair is again parallel to the gold leaf. The difference in readings on the scale denotes the angular fall.

Price for telescope with mountings complete, as illustrated, for radio-active work **$11.50**

RADIO-ACTIVE ELEMENTS. See No. **83–275.**

No. 83–200

83–200 CAST DRUM GOLD LEAF ELECTROSCOPE, for quantitative measurements of the radio-activity of substances. In the design illustrated herewith, we offer a substantial instrument that will give exact results. The housing of this form, differing from the inadequate sheet metal construction, consists of a cast metal cylinder, cast as a part of which are the supporting legs. In countersunk grooves in the front and back of this cylinder, are fastened glass windows, so that the divergence of gold leaves may readily be noted and so that the electroscope may be used as an accessory in lantern projection.

This method of mounting plates entirely obstructs draughts of air and dust and permits of ready introduction of radio-active substances, yet at the same time allows an easy access to the space within the drum. Gold leaves are suspended to a strip of metal attached to the charging rod which is thoroughly insulated in its support of pure amber of ample dimensions. To secure a more complete insulation, the amber is set in a disc of ebonite. The upper end of this charging rod is provided with a detachable ball. To preserve the charging rod from disturbing outside radio-active influences, a cylindrical cap is provided with dimensions as shown in outline.

In demonstrating that the plates of a galvanic cell are electrically charged, a pair of plates No. **83–205** is provided. One of these plates may be mounted in place of the ball above mentioned; the other is provided with an insulating handle. In place, however, of the unsatisfactory coating of shellac usually applied to the contact surfaces of these plates, we provide a thin dielectric substance which greatly increases the condensing power of the plates and, in consequence, increases the accuracy of the results obtained. Capacity tests may be made with accuracy by use of **Telescope and Scale** No. **83–170**.

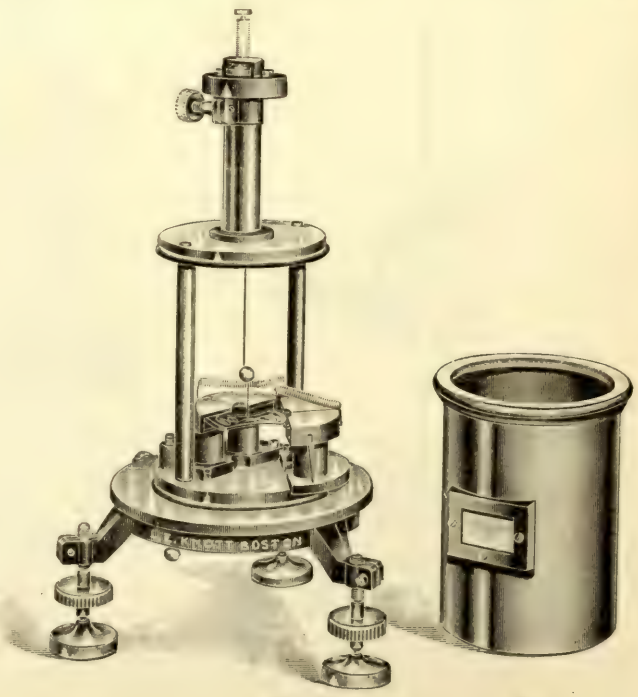
Cast Drum Gold Leaf Electroscope, complete with Cap, Plates, and Dielectric **$6.25**

83–202 CAST DRUM GOLD LEAF ELECTROSCOPE, without Plates, but with Cap **4.00**

83–205 PLATE ATTACHMENT, for use with Cast Drum Gold Leaf Electroscope, and as above described. With Dielectric **2.25**

83–215 DOLEZALEK QUADRANT ELECTROMETER. The needle and quadrants of this instrument are of small dimensions. The quadrants are mounted upon amber which affords the highest insulation. The needle is of "silver paper," its form insuring ample rigidity. It is suspended by a quartz fiber, its extreme lightness making it possible to use a very feeble controlling force without rendering the period unduly great. The resistance offered by the air to a needle of such light construction suffices to render the motion nearly dead-beat without the need of any damping device.

The needle is charged to a potential of 50 to 200 volts, which may be obtained from a voltaic battery, dry pile, or from a lighting current. To facilitate the communication of the charge to the needle, the fiber and its attachments are rendered conductive by a thin film of a hygroscopic salt. The lightness of the needle enables the instrument to be moved without fear of damaging the suspension and no arrestment, in consequence, is required. The fiber is provided with a hook at each end, these hooks engaging



No. 83–215

with eyes in the torsion head and the needle in such a way that no slip or backlash can be introduced.

Three screw feet are provided for leveling as well as a screw adjustment for varying the height of the needle within the quadrant box. The instrument can be turned in azimuth and clamped in any position. The torsion head from which the quartz fiber is suspended can also be rotated and clamped. The metal housing which serves as a protection from draughts and from stray electrostatic fields can be independently turned so that its glass window face can be viewed from any direction. Access to the needle is facilitated by mounting two adjacent quadrants so that they may be swung to one side and restored again to their working position.

All parts of this instrument are highly polished and lacquered. Most painstaking care is used in construction and assembling of parts. The instrument will be found satisfactory to the most critical . . . . . Duty Free **$55.00**

No. 83–225

83–225 MICROSCOPIC READING QUARTZ ELECTROMETER. This electrometer has two distinct parts, namely, the electrometer proper and the reading contrivance. Inside the electrometer proper, at the bottom, the leaf support is fixed in a piece of insulating amber and carries on two sloping supports the silvered quartz filaments. The charging of these filaments takes place above by means of the charging contrivance, which, as in the case of the filament supporter, is fixed in an amber plug forming at the same time the stopper of the case. The connection is made by a wire which passes into a hole in the leaf support and is pressed by means of a spring against the charging contrivance. A conical hole in the upper end of the charging contrivance allows of the insertion of a charging pin, etc. In contrast to former arrangements of leaf electrometers, in which the charging pin was led direct to the leaf support, this special charging contrivance has the advantage that the leaf support cannot become loosened in its insulator and the dust and motions of the air are kept excluded. When the electrometer is not in use, the opening above the charging contrivance is closed by means of a lid. Two small containers, noted in the illustration as projections of the case, are provided for use of calcium chloride in keeping the electrometer in a dry condition, the other for a quantity of lead acetate, to protect the silvered cylinders. The front of the case is closed by means of a plate of frosted glass; the opposite side is provided with a microscopic reading contrivance. This contrivance is ingenious in that an object lens is provided for each of the quartz filaments which hang slanting. Close behind each lens, a prism is arranged in such a way that the virtual image thrown by the lens is moved to a certain point so that the two filaments cross each other. The eye-piece is provided with a vertical micrometer scale upon which the deflections of the filaments can be read off in volts and calibrated. On this

scale, one centimeter is divided into 100 parts, the sharp definition of the cross cast by the filaments enabling an easy estimation of one tenth of each division.

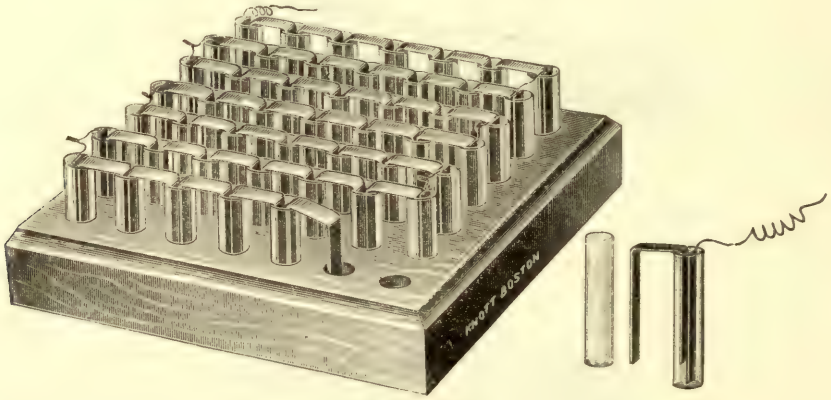
This instrument is of the most accurate construction throughout. The insulation is practically perfect and keeps excellently. A charged electrometer may be transported from place to place at will and will not discharge itself in any position. From several observations which were made, it was found that after a charge of 60 volts a loss of 4 volts occurred in 24 hours. A further advantage in this form is to be realized in the fact that for both filaments it is necessary to take but one reading which can be exceedingly accurately and quickly effected. The filaments do not move slowly to their maximum position, but, rather, jump from division to division.

The electrometer is mounted on a tripod stand and all parts are fitted to this stand in perfect adjustment. The apparatus can be quickly packed into a special case provided for the purpose.

Complete with special case . . . . . Duty Free **$62.00**

ELECTROSCOPIC ACCESSORIES

For charging the needles of electrometers and for gauging electroscopes, a battery giving real, constant and well-defined electromotive forces is essential. The Zamboni Dry Cell Piles do not fulfill requirements. Accumulators and the usual dry cells are better, but have the disadvantage of being either cumbersome or inconstant. We recommend for use the Water Battery listed below.



No. 83–250

83–250 **WATER BATTERY,** 50 cells, mounted on substantial neatly finished wooden base.
This battery is particularly adapted to advanced work when high voltage and low amperage are desired. It will be found a most serviceable battery for all electrostatic electrometer work . . . **$6.25**

83–252 ——, same as above, but comprising 100 cells. This battery is a combination of two of the above **12.75**

No. 82–75

82–75 **CHARGING ROD.** This charging rod has been designed in order to provide a simple and certain means for charging electroscopes. The charges are produced by the friction between a piece of flannel and a resinous rod. The whole is surrounded by a brass case which acts as a guide for the movable flannel ring. The rod can be used to produce either positive or negative charges **$6.50**

83–275 **RADIO-ACTIVE SUBSTANCES.** For the convenience of those who desire to make a study of radio-activities we list four of the most important substances. They are black uranium oxide, pitchblende, thorium nitrate and uranium nitrate.
Set of four in sealed glass stoppered bottles **3.00**

INSULATION AND CONDENSATION OF STATIC ELECTRICITY

No. 84–10

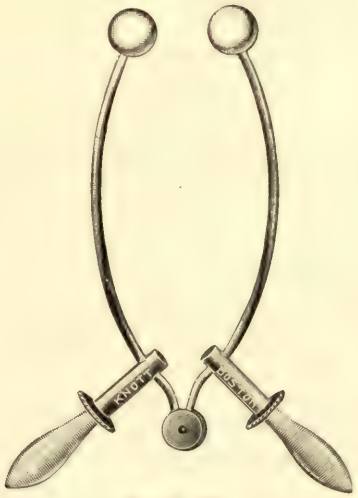
No. 84–15

84–10 **INSULATING STOOL,** valuable in insuring total insulation from the earth.
This stool is constructed with a handsomely finished hard wood top, provided with four glazed porcelain legs with knob feet, the insulating qualities of which are unexcelled, even by glass **$2.50**

84–15 **ADJUSTABLE INSULATING STAND,** solid in construction, insulating qualities sufficient for all practical purposes.
Consists of a supporting plate held adjustably by two vulcanite rods to a metal base.
Complete as illustrated **2.50**

No. 84–20

No. 84–25

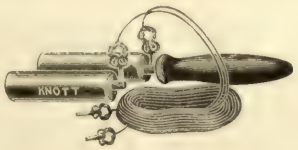


No. 84–30

84–20 **PROOF–PLANE,** simple disc type with insulating handle **$0.30**

84–25 **GUARDED DISCHARGER,** simple form, polished brass arc with ball terminals attached to a polished ebonite handle with disc ebonite guard **1.25**

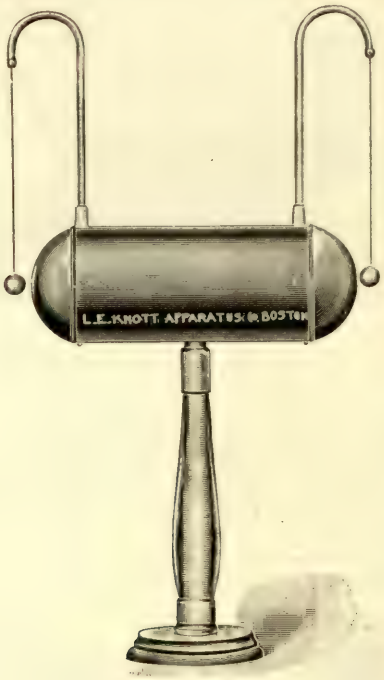
84–30 **TWO–HANDLED JOINTED DISCHARGER,** two highly polished brass arcs with knob terminals, jointed to provide an adjustable gap, each arc with insulating handle of ebonite **2.75**



No. 84–40

84–40 **SHOCKING HANDLES AND CORDS,** the standard form used in testing physiological effects of electrical discharges. Two nickel-plated metallic handles, one with insulated carrier; two conducting cords, each cord with connector tips. Per pair with cords **$1.00**

No. 84–50 to 84–55



No. 84–60

84–50 SIX-INCH INDUCTION AND DISTRIBUTION SPHERE, for showing that a charge remains on the outer surface and does not penetrate into the interior.
This sphere is made of spun brass, highly polished, having a hole in the top. It is mounted on a neat, brightly japanned base with an insulating ebonite pillar. Diameter 6 inches **$5.00**

84–55 FOUR AND ONE-HALF INCH INDUCTION AND DISTRIBUTION SPHERE, same as above but 4½ inches in diameter **2.75**

84–60 SIXTEEN-INCH INDUCTION CYLINDER, for illustrating electro-static induction.
This apparatus consists of a polished brass cylinder, 16 inches in length, mounted on an insulated support with tripod base. This cylinder is provided with movable brass supporting arms to which are attached pith balls.
If a positively charged sphere be brought near one end of the cylinder, that end will become negatively charged while the opposite end will be positive **9.25**

84–65 EIGHT-INCH INDUCTION CYLINDER, similar to above, but 8 inches long **3.50**

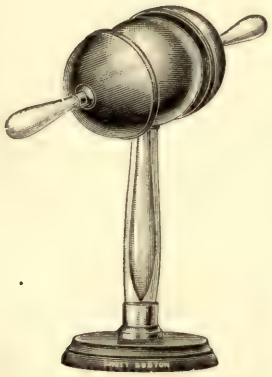
No. 84–70

84–70 HOLLOW INDUCTION CYLINDER, for demonstrating that a charge collects on the surface only.
This apparatus consists of a polished brass tube supported on an ebonite stem attached to a base. It is provided with a support for pith balls, both within and without the cylinder. When charged, pith balls without the cylinder will fly apart, while those within will remain unmoved, demonstrating that the outside only is charged **$2.70**

84–75 FARADAY'S METAL SHIELD or ELECTRIC SCREEN, for covering electroscopes, illustrating the Marconi system of selecting electric signal waves; also illustrating the principle of protection from lightning.
Mount an electroscope on a metal plate placed on a stand or on the table top. Place Screen over electroscope. Allow sparks from a Static Machine to reach the Screen and note leaves of electroscope. Remove screen and metal plate and test leaves by merely approaching a charge to the electroscope.
Metal Shield only **1.00**

No. 84–75

No. 84–80



No. 84–86

84–80 ELLIPSOIDAL CONDUCTOR, for demonstrating the tendency of static distribution.

This design consists of a polished brass ellipsoidal body mounted on an insulated stem with a neatly finished base. Size of ellipsoid, 8½ inches long, 3½ inches in diameter **$4.50**

84–85 BIOT'S HEMISPHERES, for demonstrating that a static charge seeks the outer surface of a body.

This apparatus consists of two polished brass hemispheres with insulating handles. These hemispheres are designed to fit over No. **84–55** Induction and Distribution Sphere.

When the globe is electrified and two hemispheres are placed over it, and then removed, it will be found that they have become electrified while the globe has lost its charge.

Biot's Hemispheres, only **2.25**

84–86 BIOT'S HEMISPHERES and NO. 84–55 INDUCTION AND DISTRIBUTION SPHERE, complete as illustrated **5.00**

84–90 RITCHIE'S SURFACE AND INTENSITY APPARATUS, for showing the variation of electrical density on a unit of surface as that surface is diminished or increased.

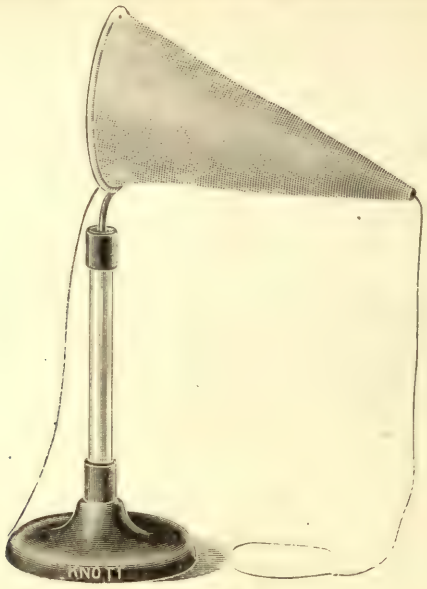
This ingenious instructive instrument consists of a special clamp in which fits the roller insulated from the clamp. Around this roller is wound tin foil. An electrometer in metallic contact with the tin foil indicates the quantity of electrical force.

When the tin foil is rolled up, a charge is imparted to it by which a certain divergence is produced on the balls of the electrometer. On unrolling the tin foil this divergence gradually diminishes but increases as it is rolled up again.

The clamp of this instrument may be attached to any 19-millimeter rod.

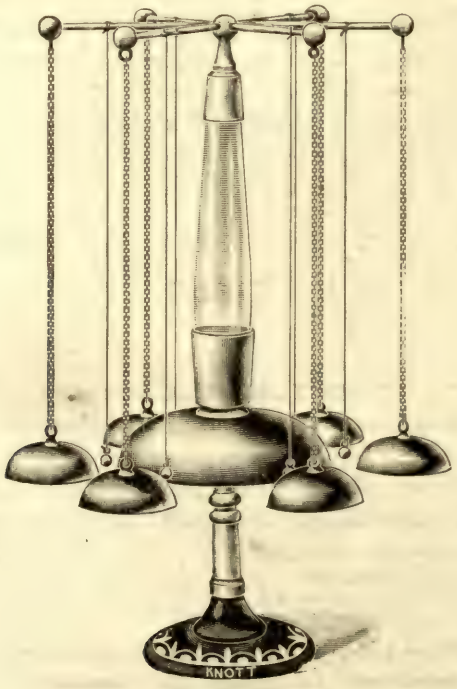
Without supporting stand **$3.80**

No. 84–90



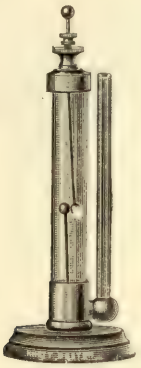
No. 84–100

84–100 FARADAY'S CONICAL NET, for demonstrating that a static charge will always reside on the outside.
This apparatus consists of a conical bag of linen gauze, supported on an insulating stand and to which are attached silk strings by which it may be turned inside out.
In use, this conical bag is charged, which, by tests, may be shown to reside on the outside only. When pulled inside out, and tested, it will be found that the charge still is on the outside, having passed through the gauze **$1.65**



No. 84–125

84–125 BELL CHIMES, illustrating electrostatic attraction and repulsion between electrified bodies.
This apparatus consists of an insulated stand to the top of which are attached three cross-heads, to the ends of each of which are attached bells suspended by brass chains. The lengths of these chains are adjusted so that all six will be in the same plane as a large bell mounted to the insulating support. Also mounted to these cross-heads are six silk cords each holding a small metal ball. The lengths of these cords are adjusted so that the balls will lie in the same plane as the bells.
When this apparatus is electrified, the small balls will be attracted and repelled between the large bell and the small bells, causing a continuous jingle **$9.00**

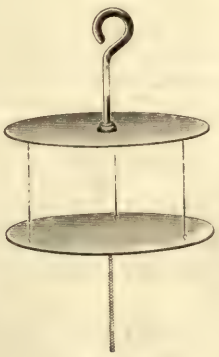


No. 84–145

84–145 KINNERSLEY'S THERMOMETER, for illustrating the disturbance and sudden expansion occasioned when electricity discharges into air, the cause of many explosions in buildings struck by lightning.

This apparatus consists of two glass tubes which fit into metal caps and communicate with each other. At the top of the large tube is a rod terminating in a knob and moving in a stuffing box. At the bottom there is a similar rod with a knob.

In use, the apparatus contains water up to the level of the lower knob. When the electric discharge passes between the two knobs, the water is driven out of the larger tube and rises in the index tube. The level, however, is immediately re-established, and therefore the phenomenon is not due to a rise of temperature, but to the sudden expansion and disturbance caused by the air in the tube. This instrument is handsomely finished throughout and will be found especially adapted for lecture table use. **$9.80**



No. 84–155

84–155 IMAGE PLATES, for illustrating the phenomenon of attraction and repulsion.

This apparatus consists of two nickel-plated discs suspended one to the other by insulating cords. To the upper disc is fastened a nickel-plated hook for attaching to the Static Machine; the lower is provided with a chain for securing connection with the ground or opposite pole of Static Machine.

In use the pith images are placed between the two plates. They will dance up and down as they become charged with positive and negative electricity **$1.80**

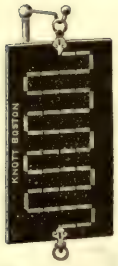
84–157 PITH IMAGES, a pair of images constructed of pith for use with No. **84–155** Image Plates. Per Pair **.50**

84–175 POLE-TEST PAPER. When two electrical leads are placed close together upon a moistened strip of this paper, the negative pole may be distinguished by the pinkish stain which it leaves. Per Sheet **.05**

ELECTROSTATIC PHENOMENA

The following accessories will be found interesting for lecture work. With even the smallest size Influence Machine, a great variety of interesting experiments may be performed. The workmanship of each accessory is accurate and under proper conditions the desired phenomena may be strikingly illustrated.

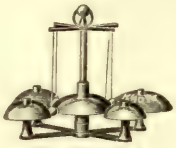
As each accessory is designed to fit our No. **84–200** Universal Stand, only one stand will be found necessary.



No. 84–212

No. 84–206

No. 84–214



No. 84–204

No. 84–210

No. 84–222

No. 84–202

No. 84–216

No. 84–208

No. 84–200

No. 84–220

No. 84–218

No. 84–224

84–200 **UNIVERSAL STAND.** May be used with all accessories listed **$1.00**

84–202 **PAPER BRUSH.** When discharged, paper strips will stand out as illustrated . . . . . **.55**

84–204 **BELL CHIMES,** consisting of five harmonically tuned bells which, when connected to Influence Machine, will cause small balls to rapidly vibrate back and forth between them **2.60**

84–206 **DANCING BALLS AND HOLDER.** Apparatus connected, the balls will dance within the holder . **2.70**

84–208 **WHIRL.** When connected to Influence Machine, charge will leap rapidly from points, causing a rotary motion . . . . . **.70**

No. 84–230

84–210 **HOLDER FOR GEISSLER TUBE AND LIGHTNING PLATE** . . . . . **.50**

84–212 **EBONITE LIGHTNING PLATE.** Spectacular sparks across gaps in tin foil when connected with Influence Machine **1.20**

84–214 **LIGHTNING SPIRAL TUBE.** Spectacular spiral of sparks across gaps in tin foil when connected with Influence Machine **1.60**

84–216 **BALL RACE.** Hollow glass sphere will race rapidly around track when connected to Influence Machine **1.65**

84–218 **SMOKE CONDENSATION APPARATUS.** The smoke from a smoke handle within a glass holder is condensed when connected to an Influence Machine, entirely disappearing **2.70**

84–220 **SHOCKING HANDLES,** for electrifying persons . **.60**

84–222 **LEYDEN JAR,** best glass, heavy tin foil covering, 4 inches high **1.10**

84–224 **DISCHARGER** **1.00**

84–226 **CONDUCTOR CHAINS,** for connecting accessories to Influence Machine . . . . . **.25**

84–230 **DEMONSTRATION SET,** for illustrating electrostatical phenomena. For the convenience of those who desire to order a complete set, we furnish the set as listed above, Nos. **84–200** to **84–226,** enclosed in a strongly constructed cardboard box divided into compartments **16.50**

SUPPLEMENTARY DESIGNS

ELECTROSTATIC PHENOMENA

No. 84–240

No. 84–244

No. 84–248

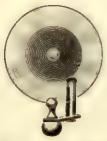
No. 84–246

No. 84–242

No. 84–250

No. 84–252

No. 84–254


No. 84–256

No. 84–258

No. 84–260

84–240 **ELECTRO-STATIC MOTOR;** the ebonite spider with the metallic balls is rotated rapidly when connected to an Influence Machine **$5.25**

84–242 **GLASS PENETRATING APPARATUS,** for producing breath pictures and for penetrating glass. When connected to an Influence Machine, the imprint of a coin will be invisible until the glass is breathed upon. With this apparatus, also, a glass plate ⅛ inch in thickness will be penetrated by a spark even from the smallest Influence Machine **3.15**

84–244 **SAND APPARATUS.** Fine glass sand placed in the funnel will emerge through the hole in the bottom in the form of a straight stream. When funnel is electrified, the sand grains will repel each other, causing the stream to spread out and the fine grains will fall with a spattering noise . . **1.95**

84–246 **QUADRANT ELECTROMETER.** When not charged, the ball will lie against the metallic rod. When charged, the ball will be repelled and according to the strength of the machine to which it is connected, will show a large or small deflection **2.35**

84–248 **ELECTRIC MORTAR.** When connected with an Influence Machine, a spark will jump across the inside of the mortar. The air is suddenly expanded and the ball lying loose on the top is thrown up into the air. If a Leyden Jar is also connected, there will be an explosion and the ball will fly to a considerable distance **1.35**

84–250 **BEETZ' ELECTROSCOPE,** for demonstrating that a charge collects on the surface only. When apparatus is electrified, the two balls at the top will fly apart while those within the cylinder will show no movement **1.65**

84–252 **CANDLE EXPERIMENT,** for demonstrating that negative electricity will repel a flame and that positive will attract. This apparatus will also show the so-called electric wind, which may be so strong that, when in proper position, the candle is extinguished. An extra ball with a point is supplied to replace one of the balls with hook on the ebonite collar. In performing this experiment, both balls with hooks must be removed from the pillars **1.95**

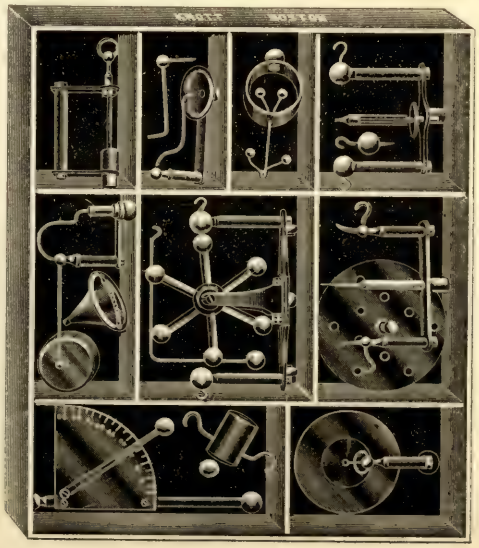
84–254 **REVOLVING DISC.** The ebonite disc which is studded with small colored circles for obtaining a better visibility is made to revolve rapidly in consequence of the radiation of the electricity from the points beneath it **$2.00**

84–256 **RADIATION APPARATUS.** After the apparatus has been connected to the Influence Machine, a luminous circle will be seen in the dark radiating from the disc to the ring **1.95**

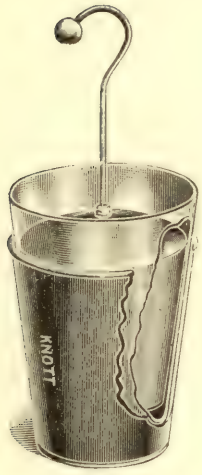
84–258 **LIGHTNING CONDUCTOR.** A small quantity of benzine or ether is placed in the small dish. The point resembling a lightning conductor is unscrewed from the knob mounted on the ebonite pillar. If a spark is now caused to strike this knob, the contents of the dish will be ignited. If point is replaced and grounded by a chain and experiment repeated, there will be no ignition as the spark will be slowly discharged through the point . **2.35**

84–260 **IGNITION APPARATUS.** By means of a spark from a Leyden Jar, small pieces of ignition paper are ignited. With extra supply of ignition paper **1.75**

84–265 **SUPPLEMENTARY DEMONSTRATION SET,** consisting of Nos. **84–240** to **84–260** together in a strongly constructed wood-reinforced cardboard box, divided into compartments . **19.75**


No. 84–265

STORAGE OF STATIC ELECTRICITY



No. 85–10

No. 85–15

No. 85–20

No. 85–40

85–10 DEMONSTRATION LEYDEN JAR, for demonstrating that an electric charge resides as potential energy in the glass of a Leyden Jar and not in the metallic coatings.
This is a dissectible Leyden Jar, the outer metallic covering being removable as well as the inner. The inner is provided with a rod with ball terminal for charging. This form must not be confused with the many types on the market. We use a special form of toughened glass for our glass jar and our coatings are of polished brass. The instrument presents a handsome appearance and readily recommends itself in comparison with other makes **$3.25**

85–15 QUART LEYDEN JAR, for storing static electricity.
This jar is constructed of a special quality of toughened glass, the coatings being smoothly applied. Provided with insulating cover through which passes a rod, one end of which is terminated in a knob. To the other is attached a chain making connection with the inner coating **1.60**

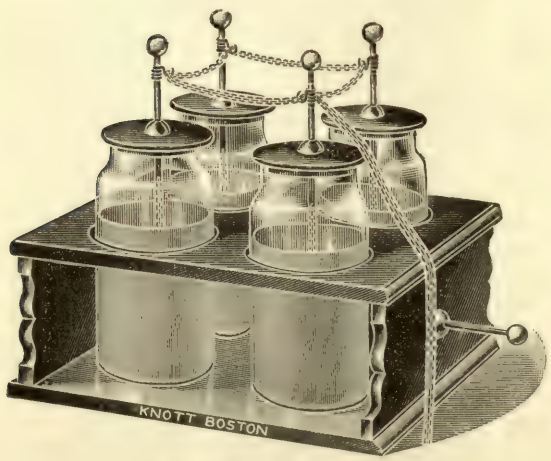
85–20 TWO-QUART LEYDEN JAR, same quality as above **2.00**

85–25 LEYDEN JAR, as used on our 12-inch Toepler-Holtz Influence Machines **1.00**

85–30 LEYDEN JAR, as used on our 16-inch Toepler-Holtz Influence Machines **1.10**

85–40 LUMINOUS LEYDEN JAR, for demonstrating optically the distribution of static electricity over the surface of a condenser being charged and discharged.
This jar is of the same size as our No. **85–20,** but is coated inside and out with a tin-foil coating which is not continuous but cut diamond-shaped **3.15**

LEYDEN JAR BATTERIES



No. 85–65

These consist of a series of Leyden Jars as previously listed arranged so that their inner coatings are connected to one terminal and their outer coatings to another, thus securing a larger area of coated surface than is contained in one jar. With an arrangement, therefore, of more than one jar connected in this manner it can be demonstrated that the capacity of a condenser is directly proportional to the area of its coated surface. This will be demonstrated by the greater time it takes to charge the battery and the more powerful spark obtained.

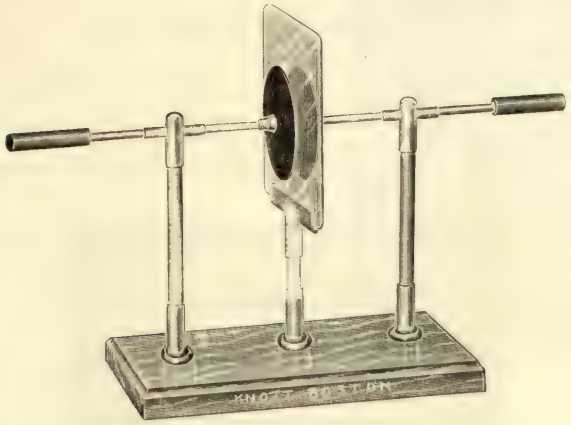
In the form of battery above illustrated we furnish one in which all connections are open to view. The jars are made of the same high quality of di-electric glass as used in all our Leyden Jars. They are placed in a box lined with heavy tin foil which serves to connect the outer coatings with the jars. The inner coatings are connected by means of brass chain.

85–60 TWO-JAR LEYDEN BATTERY $6.80

85–65 FOUR-JAR LEYDEN BATTERY . . . 11.70

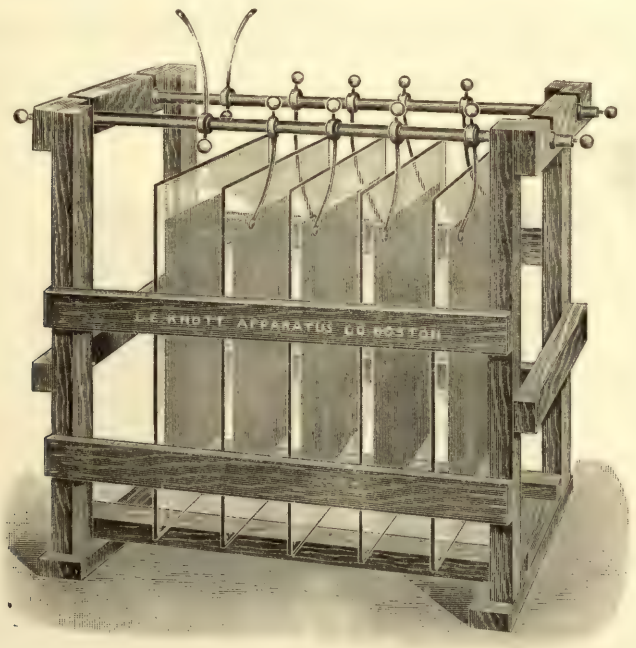
85–70 SIX-JAR LEYDEN BATTERY 16.00

PLATE CONDENSERS



No. 85–100

85–100 **DISSECTIBLE DEMONSTRATION PLATE CONDENSER,** for a study of induction in a condenser.
This apparatus consists of a neatly finished wooden base on which are mounted three insulating uprights. On the central upright is mounted a glass plate, on each of the others a rod sliding in a hole at the top of the upright. Each rod carries at one end a brass plate, at the other an insulating handle. All parts are carefully assembled and metal work polished and lacquered.
By means of a suitable electrometer the density and distribution of a charge under various conditions may be readily determined $9.60



No. 85–110

85–110 **MOUNTED GLASS PLATE CONDENSER,** for use as a Leyden Jar Battery in accumulating and storing static charges.
This condenser consists of a neatly finished hardwood frame in which are mounted five condenser plates constructed of the best quality toughened glass and having a total condensing surface area of 1620 square centimeters. Two parallel conductor rods mounted at the top of the frame over the plates and provided with contact arms for connecting any number of plates desired up to five, serve to charge the condenser.
Complete as illustrated $14.50

ELECTRICAL DISCHARGE TUBES

GEISSLER TUBES

Our collection of **GEISSLER TUBES** has been selected with the greatest care, the basis of selection being that of the greatest color effects with didactic illustrative features. These tubes are manufactured by one of the most prominent manufacturers in Europe whose name is a sufficient guarantee of quality. Each tube is provided with strong terminals sealed securely in a manner to obviate frequent breakages at terminal points.

These tubes are constructed of uranium and white glass formed into various shapes for producing pleasing optical effects. The air is then evacuated and the tubes are sealed.

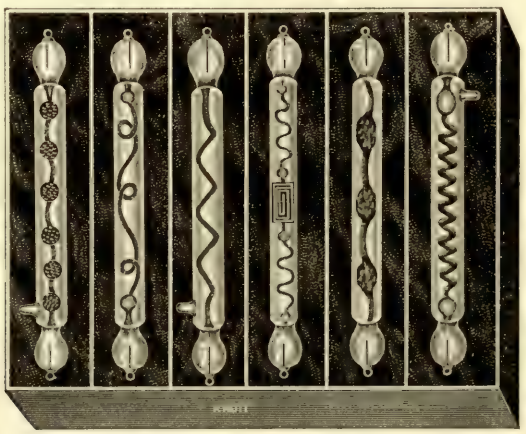
No. 86–10

86–10 **GEISSLER TUBES,** plain, set of six different shapes, 6 inches (15 centimeters) long, enclosed in neat cardboard case **$3.00**

86–11 ——, same as above . . . . . Each **.50**

86–15 **GEISSLER TUBES,** similar to above, but more complicated in form, presenting more pleasing effects, set of six, 12 inches (30 centimeters) long, in neat cardboard case **5.70**

86–16 ——, same tubes as contained in above set . . . . . Each **.95**



No. 86–25

86–25 **FLUORESCENT GEISSLER TUBES.** These tubes are constructed in a manner similar to above, but filled with fluorescent liquids such as eosine, quinine, kerosene, aesculine, and uranine. These tubes present very handsome colors and are highly recommended. Set of six, 6 inches (15 centimeters) long, enclosed in neat cardboard case **$5.40**

86–26 ——, same tubes as contained in above set . . . . . Each **.90**

86–30 **FLUORESCENT GEISSLER TUBES,** similar to above, but more complex in form. Length 12 inches (30 centimeters). Set of six in neat cardboard case **9.90**

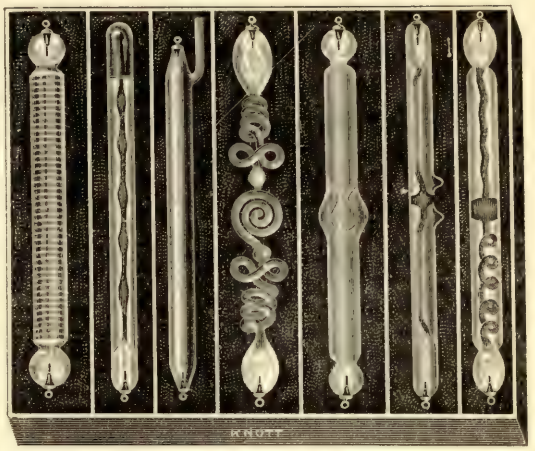
86–31 ——, same tubes as contained in above set . . . . . Each **1.65**

86–40 FOURTEEN-INCH LECTURE TABLE GEISSLER TUBES. These tubes are designed to illustrate the principal types of Geissler tubes.

They are 14 inches (35 centimeters) long and give remarkably beautiful results. Set of seven tubes as follows:

(1) Double Tube, containing two fluorescent liquids.
(2) Double Tube, containing two phosphorescent substances.
(3) Highly Evacuated Tube, constructed of uranium and white glass.
(4) Double Tube, containing two gases.
(5) Mercury Tube. Will show phosphorescence by shaking mercury in the tube.
(6) Tube containing a mercury salt which changes colors as heated.
(7) Tube showing layers of light.

Set complete, in neat cardboard case **$14.80**



No. 86–40

86–45 FLUORESCENT GEISSLER TUBE, containing two fluorescent liquids, illustrating fluorescence of different colored liquids . . **2.35**

86–46 PHOSPHORESCENT GEISSLER TUBE, containing two phosphorescent substances **$2.10**

86–47 GEISSLER TUBE, constructed of uranium and white glass, highly evacuated, to illustrate colors through different qualities of glass **2.00**

86–48 GEISSLER TUBE, containing two different gases **2.00**

86–49 PHOSPHORESCENT MERCURY TUBE. This tube does not require use of influence machine or induction coil as phosphorescence of the mercury may be shown by simply shaking it from one end of the tube to the other **2.60**

86–50 PHOSPHORESCENT GEISSLER TUBE, containing a mercury salt which exhibits different colors as it is heated **2.10**

86–51 GEISSLER TUBE, constructed to show various strata of light **2.00**

No. 86–60

No. 86–62

No. 86–64

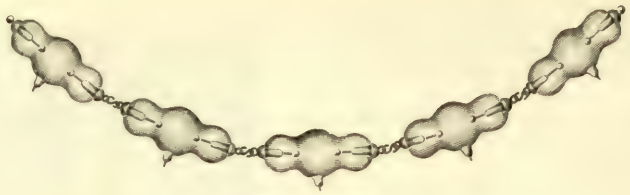
No. 86–66

86–60 GEISSLER TUBE, improved form, constructed of uranium and white glass and filled with various fluorescent liquids, mounted on glass foot, and provided with strengthened terminals for connection to Influence Machine or Induction Coil. Height 6 inches **$1.65**

86–62 GEISSLER TUBE, improved form, as above, but of different shape and more complicated design. Height 6 inches (15 centimeters) **1.75**

86–64 GEISSLER TUBE, similar to above, but more complicated design, height 6 inches (15 centimeters) **1.95**

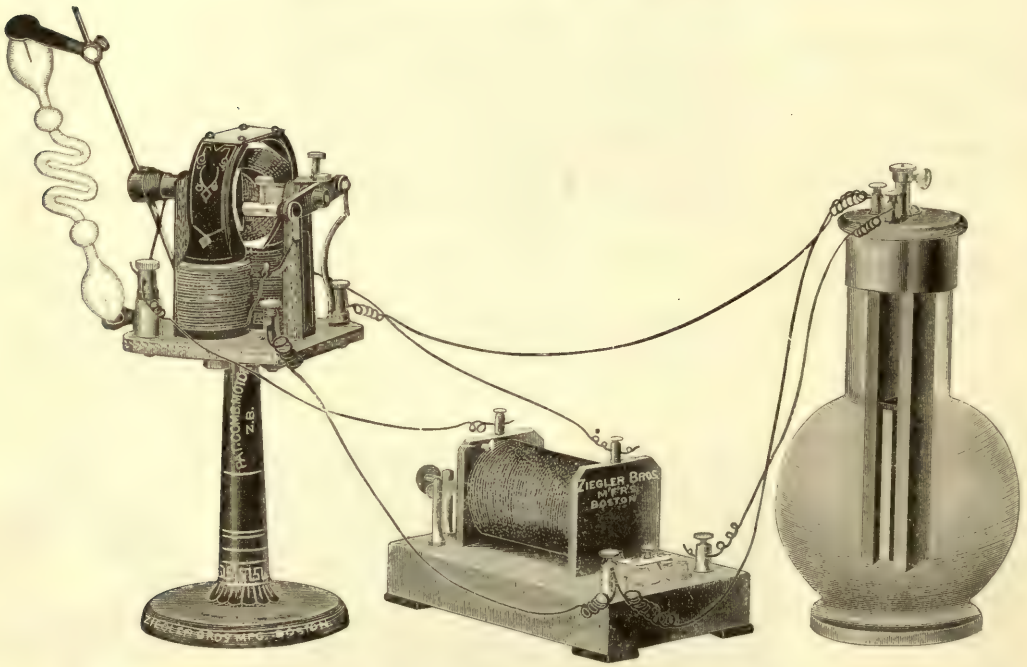
86–66 GEISSLER TUBE. The design illustrated excels in colors. It is designed to show fluorescence of three different colored liquids and two gases, as well as the colors of uranium and white glass. It is mounted on glass foot and is 6 inches (15 centimeters) high **2.25**



No. 86–75

86–75 **UNEQUALLY EVACUATED GEISSLER TUBES,** for showing effects upon a spark as it passes through tubes filled with unequally attenuated air.
This apparatus consists of five connected Geissler Tubes, each of which has a different degree of exhaustion.
In the least exhausted tube the spark is well defined, but as the vacuum increases, this spark begins to widen out and fill the whole tube, becoming pale in tint and nebulous in form . . . Per set of five **$8.90**

GEISSLER TUBE ROTATORS



No. 86–100

86–100 **GEISSLER TUBE ROTATOR,** for rotating Geissler Tubes to increase the spectacular effect.
Our rotator consists of a practical motor (not a toy) constructed after designs of the expensive commercial types. It is mounted upon a substantial metal pedestal support and is provided with appropriate binding posts, one pair for battery or other current and one pair for induction coil or Influence Machine. The Geissler tube is attached to the holder, which may be firmly fixed to the spindle of the rotator. This holder is adjustable to take any Geissler tube up to 12 inches in length. This rotator and Geissler tube holder is illustrated connected to an induction coil and battery ready for use.
Motor only, with Geissler tube attachment, motor wound for battery current **$12.00**

86–102 ——, same as above, but motor wound for 110 volts, D. C. **13.75**

86–104 ——, same as above, but motor wound for 110 volts, A. C. **13.75**

86–110 **GEISSLER TUBE HOLDER,** for use with our No. **21–10** Mechanical Rotator or our No. **21–30** Motor Rotator, to hold Geissler Tubes for rotation.
This holder can be firmly attached to the spindle of either of these rotators and is adjustable to hold all sizes of Geissler tubes up to 12 inches long. **4.50**

SPECTRUM AND VACUUM TUBES

Nos. 77–225 to 77–236

No. 77–245

77–225 **GEISSLER SPECTRUM TUBE,** most careful construction, filled with carbon dioxide **$1.65**

77–226 ——, filled with hydrogen gas **1.65**

77–227 ——, filled with nitrogen gas **1.65**

77–228 ——, filled with oxygen gas **1.65**

77–235 **GEISSLER SPECTRUM TUBE,** most carefully constructed, evacuated, and filled with pure argon gas **7.25**

77–236 ——, same as above, but filled with helion **7.25**

77–245 **GEISSLER SPECTRUM TUBE,** for evacuating and filling with whatever gas desired. Fitted with two carefully ground glass cocks **1.65**

86–150 **DE LA RIVES APPARATUS,** for showing that magnets act on light in Geissler tubes in accordance with the laws with which they act on any other movab e conductor.

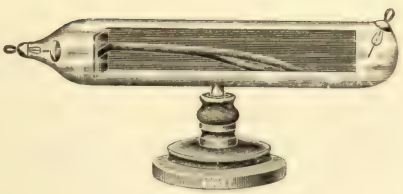
The apparatus consists of a highly evacuated bulb sealed into the lower end of which, and extending up into the bulb, is a tube, into which extends a rod of soft iron. This rod, in use, is magnetized by an electro-magnet.

Terminals of the bulb are connected to an electro-static current or current from an induction coil, and a beam of light passes from one terminal to the other. When the voltaic current is turned through the electro-magnet, this beam of light turns slowly about the magnetized rod, sometimes in one direction, sometimes in the other, according to the direction of the induced current or of the induced magnetism.

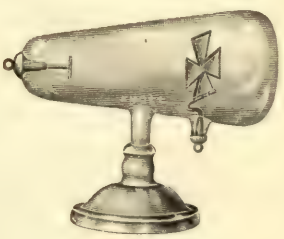
Complete with electro-magnet **$5.90**

No. 86–150

No. 86–160



No. 86–165



No. 86–170

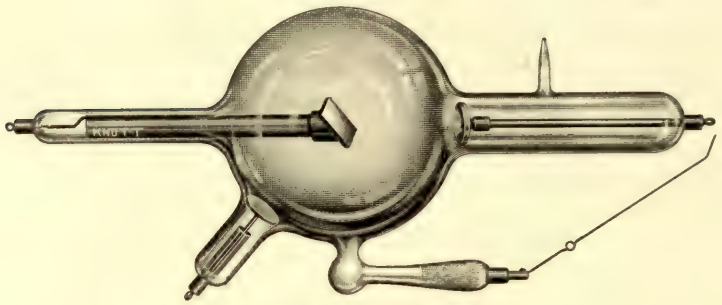
86–160 **VACUUM TUBE,** for showing the heating effect of the cathode ray. The negative electrode is in the form of a mirror, designed to focus the cathode ray upon a piece of platinum foil, heating it white hot in a very short time **$7.50**

86–165 **VACUUM TUBE,** for showing the deflection of a cathode ray. On one side of an evacuated tube is a fluorescent screen with a strip with slit at right angles. This strip absorbs the cathode rays except those which pass through the slit. By holding a magnet to the tube, it may be shown that this beam is deflected as indicated by its path on the fluorescent screen **5.75**

86–170 **VACUUM TUBE,** for showing the power of a body to interpose the cathode ray. When the discharge passes, the cathode rays proceed in straight lines. The small cross, however, interposes a number of these molecules and a shadow of the cross is cast on the opposite side of the tube . . . **6.80**

ROENTGEN RAY APPARATUS

X-RAY TUBES



Nos. 87–40 to 87–50

The following four tubes are for use with small enclosed Static Machines and Spark Coils operated by battery current which give sparks of from four to six inches in length. We frequently have requests for X-Ray tubes to be used with small unenclosed Static Machines and small Ruhmkorff Coils, but none of these tubes will give satisfactory results and we have not included any in this series.

87–10 **AUTOMATICALLY ADJUSTED X-RAY TUBE,** 4 inches in diameter with heavy platinum target and with special attachment for maintaining automatically the proper degree of vacuum . . . **$9.80**

87–15 **X-RAY TUBE,** 4 inches in diameter with heavy platinum anode the same as above, but without the automatic adjuster **7.50**

87–20 **AUTOMATICALLY ADJUSTED X-RAY TUBE,** 5¼ inches in diameter with heavy platinum anode and with automatic adjuster **12.25**

87–25 ——, 6 inches in diameter with heavy platinum anode and automatic adjuster **16.40**

The following three tubes are for use with large enclosed Static Machines and with large Induction Coils operated by power current with Electrolytic Interrupter.

87–40 **AUTOMATICALLY ADJUSTED X-RAY TUBE,** 6 inches in diameter with heavy platinum anode and automatic adjuster **$22.00**

87–45 ——, 7 inches in diameter with heavy platinum anode and automatic adjuster **27.75**

87–50 ——, 8 inches in diameter with heavy platinum anode and automatic adjuster **33.50**

The following two tubes are for use with Tesla and High Frequency Coils.

87–60 **AUTOMATICALLY ADJUSTED X-RAY TUBE,** 5¼ inches in diameter with especially constructed platinum anode and automatic adjuster **20.40**

87–65 ——, 6 inches in diameter with especially constructed platinum anode and automatic adjuster . . **22.60**
(We recommend the use of the above two tubes with our High Frequency Coils, Section **95**.)

The following three tubes are recommended for the very heaviest machines and the most exacting work that can be put upon the X-Ray tube. The anode is of heavy sheet Tungsten which will fuse only at a temperature of 3000 Centigrade, and for X-Ray work is practically indestructible. These three tubes are the latest and best product in X-Ray tube construction.

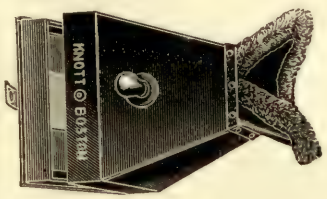
87–70 **TUNGSTEN X-RAY TUBE,** latest construction, 6 inches in diameter **$38.00**

87–75 ——, same as above, 7 inches in diameter **44.50**

87–80 ——, 8 inches in diameter **49.25**

87–100 SMALL X-RAY STAND, universal adjustment **$2.00**

87–110 LARGE X-RAY STAND, with heavy iron base. This stand is four feet tall and is arranged for adjustment in all directions **11.00**



Nos. 87–125 to 87–145

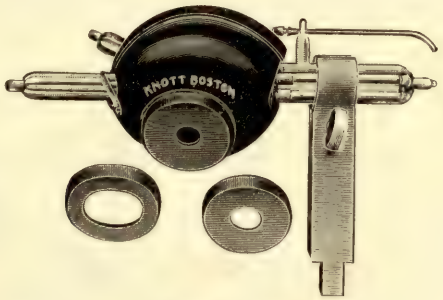
87–125 BARIUM PLATINO-CYANIDE FLUOROSCOPE AND SCREEN, 3 × 4 inches **$8.25**

87–127 BARIUM PLATINO-CYANIDE FLUOROSCOPE AND SCREEN, 5 × 7 inches . . **12.50**

87–130 BARIUM PLATINO-CYANIDE FLUOROSCOPE AND SCREEN, 6 × 8 inches **17.50**

87–140 CALCIUM TUNGSTATE FLUOROSCOPE AND SCREEN, 5 × 7 inches **10.00**

87–145 CALCIUM TUNGSTATE FLUOROSCOPE AND SCREEN, 6 × 8 inches **12.50**



No. 87–175

87–175 PROTECTOR, for X-Ray Tube. This Protector is of rubber and will fit over all sizes of tubes up to six inches in diameter **$8.75**

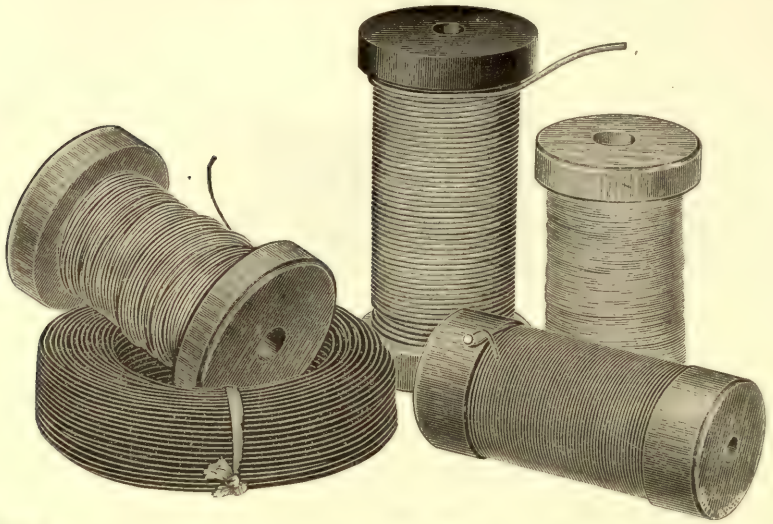
87–180 PROTECTOR, for large X-Ray Tubes. This Protector is made of glass containing approximately 40 per cent of lead, and should be used with tubes measuring 7 inches and 8 inches in diameter . **13.50**

No. 87–190

87–190 EYE GLASS PROTECTOR to be worn by operator when doing X-Ray work **$3.00**

ELECTRICITY

ELECTRICAL SUPPLIES



90–10 COPPER WIRE, bare.

	a	b	c	d	e	f	g	h	i
B. & S. Gauge	16	18	20	22	24	26	27	28	30
Price per 1 oz. Spool									$0.18
Price per 4 oz. Spool			$0.22	.24	.28	.30	.32	.33	.27
Price per 1 lb. Spool	$0.50	.52	.54	.60	.65	.68	.70	.72	

90–15 COPPER ANNUNCIATOR WIRE, double cotton covered, paraffined. B. & S. Gauge No. 18
Per ½ Pound Coil **$0.35**
Per Pound Coil **.55**

90–20 COPPER WIRE, double cotton covered.

	a	b	c	d	e	f	g	h	i	j
B. & S. Gauge	16	18	20	22	24	26	27	28	30	36
Price per 4 oz. Spool			$0.35	.38	.40	.50	.52	.55	.60	1.15
Price per 1 lb. Spool	$0.67	.70	.76	.90	1.00	1.25	1.30	1.45		

90–25 COPPER WIRE, enamel coated.

	a	b	c
B. & S. Gauge	28	30	36
Price per 4 oz. Spool	$0.85	1.35	1.95

90–30 FLEXIBLE WIRE, TINSEL WIRE, covered with green twisted braid . . . . . Per Yard **$0.10**

90–35 LAMP CORD, two conductors twisted, B. & S. Gauge No. 18, rubber and cotton insulation. Per Yard **.15**

90–40 THEATRE CABLE, for 40 amperes current; advisable for use in lantern projection. This cable consists of two conductors, flexible, cotton wrapped, rubber covered, braided, twisted together with filler, and finished with two weather-proof braids . . . . . Per Yard **1.05**

90–45 SPRING BRASS WIRE.

	a	b	c	d	e
B. & S. Gauge	22	24	27	28	30
Price per 4 oz. Spool	$0.22	.26	.33	.35	.36

90–50 FUSE WIRE.

	a	b	c	d	e	f	g
Amperes	½	1	3	5	10	15	35
Price, per yard	$0.06	.07	.08	.10	.15	.20	.35

90–55 GERMAN SILVER WIRE, 18 per cent alloy, bare.

	a	b	c
B. & S. Gauge	26	28	30
Price per 4 oz. Spool	$0.48	.54	.60

90–60 GERMAN SILVER WIRE, 18 per cent alloy, single cotton covered.

	a	b	c	d
B. & S. Gauge	18	20	28	30
Price per 4 oz. Spool		$0.75	1.10	1.20
Price per 1 lb. Spool	$1.50			

90–70 IRON WIRE, soft drawn, bare.

	a	b	c	d
B. & S. Gauge	24	27	28	30
Price per 4 oz. Spool	$0.15	.18	.19	.20

90–75 IRON PICTURE WIRE, No. 1 . . . . . Per Package **$0.10**

90–80 LEAD WIRE, ⅛ inch diameter . . . . . Per Foot **.06**

90–85 MAGNESIUM RIBBON, per five gram roll . . . . . **.30**

90–90 MANGANIN WIRE, double cotton covered, an alloy of manganin, nickel and copper. Excellent for use in manufacture of high-grade measuring instruments. Temperature coefficient, .00001.

	a	b
B. & S. Gauge	18	20
Price per 4 oz.	$1.05	1.25

90–92 ——, similar to above, but double silk covered.

	a	b	c	d
B. & S. Gauge	24	28	30	36
Price per 1 oz.	$0.68	.85	1.00	1.60

57–10 PIANO WIRE, best quality imported, wound in coils, each weighing approximately ¼ pound.

	a	b	c	d
Diameter, inch	.028	.022	.0178	.014
Per Coil	$0.40	.40	.80	1.10

90–100 PLATINUM WIRE.

	a	b	c	d	e	f
B. & S. Gauge	20	22	24	26	28	30

In view of the continual market fluctuations in the price of Platinum, we quote only on application.

90–105 ZINC WIRE, ⅛ inch diameter . . . . . Per Foot **$0.08**

90–150 ARTIFICIAL LIGHT CIRCUIT, for reproducing, within the laboratory, conditions similar to those of an actual incandescent lighting circuit as worked out in the Applied Electrical Laboratory of Pratt Institute.

A wire of known high resistance per mil-foot, resembling in appearance an ordinary incandescent lighting wire, but having an asbestos insulation to avoid danger of fire. In use this wire is strung along the side of a room or mounted on a movable frame using standard porcelain insulators and cleats, lamp sockets and switches.

Fifty-foot Artificial Lighting Circuit complete with special resistance wire, sufficient insulators, cleats, lamp sockets and switch, with full directions and diagrams for setting up **8.75**

CONNECTORS

90–185 THE "PRIMO" POSITIVE CONTACT LECTURE TABLE CLASPS. These connectors are recommended for rapid connections in lecture table work. Connections to all styles of binding posts, both bare and insulated wire, can be made in an instant. The grip with teeth makes an excellent contact even through heavily insulated wires . . . . . Per Pair **$0.60**

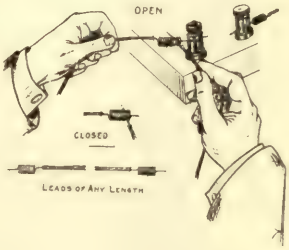
90–187 THE "PRIMO" POSITIVE CONTACT LECTURE TABLE CONNECTOR. Consists of a pair of No. **90–185** Clasps with a 4-foot length of flexible, heavily insulated copper wire. Each **.80**

Nos. 90–185 to 90–187

THE IMPROVED RAPID BATTERY CONNECTORS

Patent Pending

Nos. 90–175 to 90–180



As will be suggested from the cut, these battery connectors are made of a carefully proportioned spiral spring of phosphor-bronze wire, the proper size to give sufficient rigidity and at the same time to make them easy of connection.

The spirals being separated by a slight pull, the straight end of the next connector is readily slipped in place, making a secure electric contact which will not accidentally loosen in the course of the experiment.

These terminals are especially serviceable in laboratory work, since they have the important feature of being connected with equal facility to either an English or American form binding post. For parallel or multiple connection they are equally well suited. The use of this connector, therefore, does away with the multiplicity of connectors designed for meeting the conditions of various kinds of binding posts. It frequently happens that one type of instrument having an English post has to be connected with another having an American post. With the usual form of connectors this condition is very hard to meet. With the "Rapid" this difficulty is entirely overcome.

Please note the diagram for methods of connecting to English posts, to American posts, and for connecting in multiple and parallel circuits.

As will be noted from the listing below, these connectors are furnished in pairs or in quantity, without wire connections, also furnished with wire connections of varying length.

90–175 THE IMPROVED RAPID CONNECTING TIPS . . . . . Per Dozen **$0.25**
Per Hundred **2.00**

90–177 THE IMPROVED RAPID CONNECTORS, attached to connecting cord 6 inches long, especially designed for close connection, such as joining batteries in multiple and in series . . . . Per Pair **.20**

90–179 THE IMPROVED RAPID CONNECTORS, attached to a connecting cord 2 feet long. Per Pair **.30**

90–180 THE IMPROVED RAPID CONNECTORS, attached to a connecting cord 3 feet long. Per Pair **.40**

SIZE, WEIGHT, RESISTANCE OF ANNEALED COPPER WIRE

SPECIFIC GRAVITY 8.89

		BARE					DOUBLE COTTON COVERED		
Number of Wire Gauge	American, or Brown & Sharpe (B. & S.)	Area in Circular Mils d^2	Pounds per 1,000 feet	Feet per Pound	Feet per Ohm At 50° C. or 122° F.	Ohms per 1,000 feet At 20°C. or 68° F.	Dia. over Ins. Mils dx	Wires per In. $\frac{1{,}000}{dx}$	Wires per Sq. In. $\frac{(1{,}000)^2}{dx}$
0000	.46000	211,600	640.5	1.561	18,290	.04893			
000	.40964	167,805	508.0	1.969	14,510	.06170			
00	.36480	133,079	402.8	2.482	11,500	.07780			
0	.32486	105,534	319.5	3.130	9,123	.09811	339	2.94	8.64
1	.28930	83,694	253.3	3.947	7,235	.1237	303	3.30	10.8
2	.25763	66,373	200.9	4.977	5,738	.1560	272	3.67	13.4
3	.22942	52,634	159.3	6.276	4,550	.1967	242	4.13	17.0
4	.20431	41,742	126.4	7.914	3,608	.2480	216	4.62	21.3
5	.18194	33,102	100.2	9.980	2,862	.3128	194	5.15	26.5
6	.16202	26,250	79.46	12.58	2,269	.3944	174	5.74	32.9
7	.14428	20,816	63.02	15.87	1,800	.4973	156	6.41	41.0
8	.12849	16,509	49.98	20.01	1,427	.6271	141	7.09	50.2
9	.11443	13,094	39.63	25.23	1,132	.7908	126	7.93	62.8
10	.10189	10,381	31.43	31.82	897.6	.9972	112	8.92	79.5
11	.090742	8,234.0	24.93	40.12	711.8	1.257	101	9.90	98.0
12	.080808	6,529.9	19.77	50.59	564.5	1.586	91	10.9	118
13	.071961	5,178.4	15.68	63.79	447.7	1.999	82	12.1	146
14	.064084	4,106.8	12.43	80.44	355.0	2.521	74	13.5	182
15	.057068	3,256.7	9.858	101.4	281.5	3.179	67	14.9	222
16	.050820	2,582.9	7.818	127.9	223.3	4.009	59	16.9	285
17	.045257	2,048.2	6.200	161.3	177.1	5.055	53	18.8	353
18	.040303	1,624.3	4.917	203.4	140.4	6.374	48	20.8	432
19	.035890	1,288.1	3.899	256.5	111.4	8.038	43	23.2	538
20	.031961	1,021.5	3.092	323.4	88.31	10.14	40	25.0	625
21	.028462	810.10	2.452	407.8	70.03	12.78	36.5	27.3	745
22	.025347	642.40	1.945	514.2	55.54	16.12	33.0	30.3	918
23	.022571	509.45	1.542	684.4	44.04	20.32	30.6	32.6	1060
24	.020100	404.01	1.223	817.6	34.93	25.63	28.1	35.5	1,260
25	.017900	320.40	.9699	1020	28.01	32.31	25.9	38.6	1,480
26	.015940	254.10	.7692	1300	21.97	40.75	23.9	41.8	1,740
27	.014195	201.50	.6100	1639	17.42	51.38	22.2	45.0	2,020
28	.012641	159.79	.4837	2067	13.82	64.79	20.6	48.5	2,350
29	.011257	126.72	.3836	2607	10.96	81.70	19.3	51.8	2,680
30	.010025	100.50	.3042	3287	8.688	103.0	18.0	55.5	3,080
31	.008928	79.70	.2413	4145	6.890	129.9	16.9	59.1	3,490
32	.007950	63.21	.1913	5227	5.464	163.8	15.9	62.8	3,940
33	.007080	50.13	.1517	6591	4.333	206.6	15.1	66.2	4,380
34	.006305	39.75	.1203	8311	3.436	260.5	14.3	69.9	4,880
35	.005615	31.52	.09543	10480	2.725	328.4	13.6	73.5	5,400
36	.005000	25.00	.07568	13210	2.161	414.2	12.0	83.3	6,930
37	.004453	19.82	.06001	16660	1.714	522.2			
38	.003965	15.72	.04759	21010	1.359	658.5			
39	.003531	12.47	.03774	26500	1.078	830.4			
40	.003145	9.89	.02993	33410	.8548	1,047			

RESISTANCE OF GERMAN-SILVER WIRE

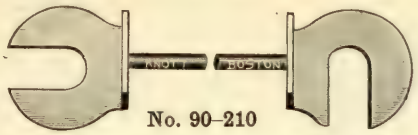
B. & S. G. No.	Resistance per 1,000 Feet International Ohms		B. & S. G. No.	Resistance per 1,000 Feet International Ohms	
	18% Wire	30% Wire		18% Wire	30% Wire
6	7.20	11.21	21	232.92	362.32
7	9.12	14.18	22	295.38	459.48
8	11.54	17.95	23	370.26	575.96
9	14.55	22.63	24	468.18	728.28
10	18.18	28.28	25	590.22	918.12
11	22.84	35.53	26	748.08	1,163.68
12	28.81	44.82	27	937.98	1,459.08
13	36.48	56.75	28	1,191.24	1,853.04
14	46.17	71.82	29	1,481.22	2,304.12
15	58.21	90.55	30	1,891.8	2,942.8
16	72.72	113.12	31	2,388.6	3,715.6
17	93.40	145.29	32	2,955.6	4,597.6
18	118.20	183.87	33	3,751.2	5,835.2
19	145.94	227.02	34	4,764.6	7,411.6
20	184.68	287.28	35	6,031.8	9,382.8

COMPARATIVE RESISTANCES

Comparative resistances of various materials taking copper as 1.

To find the resistance of any wire, first get the resistance of the same length and size of copper wire, then multiply this by figure below for the wire used.

Copper	1	Soft Steel	8	30% German Silver	28	Silver	.98	Phosphor-Bronze	3
Norway Iron	7	18 % German Silver	18	Climax	50	Aluminum	1.8	Platinum	5.5



No. 90–210

90–200 INSULATING TAPE, made from heavy cloth fabric of best quality, saturated with a preservative and adhesive compound; width ¾ inch . . . . . Per ⅓ pound package . **$0.20**

90–210 LINK FUSES, terminals having one slot parallel and one slot at right angles to the length of the fuse.

	a	b	c	d	e	f	g	h
Amperes . . .	5	10	20	30	40	50	75	100
Slots, inch . .	3/16	3/16	3/16	3/16	7/32	7/32	7/32	7/32
Each	**$0.05**	**.06**	**.07**	**.08**	**.09**	**.10**	**.11**	**.12**

FUSE WIRE. See No. **90–50.**

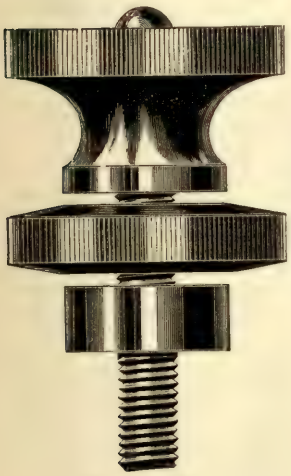
BINDING POSTS, CONNECTORS, ETC.

All of our binding posts, connectors, etc. are manufactured in our own shop, accurately made from the best material, using special tools. By manufacturing in large quantities we are able to supply them at prices which will compare favorably with those commonly charged for similar articles of inferior material and workmanship. We desire to emphasize the fact that all binding posts leaving our factory are **finished** handsomely, polished and lacquered.

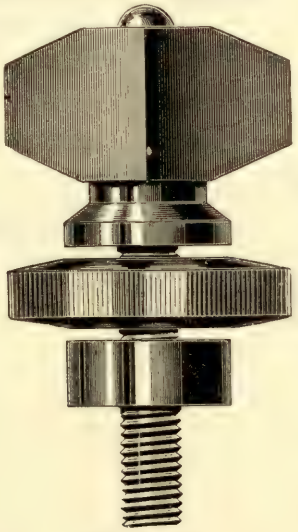
When ordering binding posts state whether screws and washers are desired or not. If screws are wanted state whether wood or machine, round or flat headed, and length.

At an additional expense of one cent each a screw of any kind or size, together with either one or two washers, will be supplied.

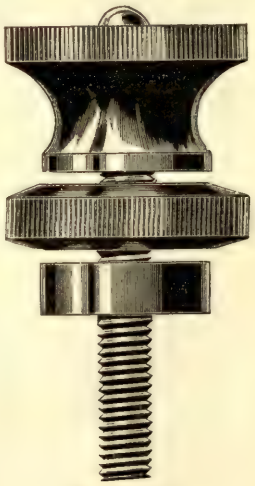
Each article herewith illustrated is represented full size.



No. 90–225
Each . **$0.75**



No. 90–235
Each . . **$1.00**



No. 90–230
Each . . **$0.75**

No. 90–240
Each . . **$0.45**

No. 90–242
Each . . **$0.38**

No. 90–245
Each . . **$0.45**

No. 90–247
Each . . **$0.26**

No. 90–250
Each . $0.14

No. 90–252
Each . $0.18

No. 90–254
Each . $0.40

No. 90–260
Each . $0.13

No. 90–262
Each . $0.12

No. 90–264
Each . $0.12

No. 90–265
Each . $0.12

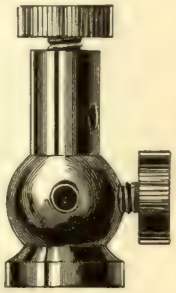
No. 90–270
Each . $0.30

No. 90–272
Each . $0.18

No. 90–274
Each . $0.15

No. 90–275
Each . $0.10

No. 90–280
Each . $0.20

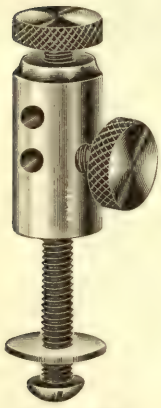


No. 90–282
Each . $0.25

No. 90–284
Each . $0.16

No. 90–286
Each . $0.12

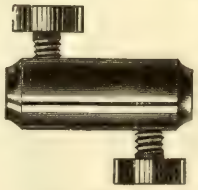
No. 90–288
Each . $0.10



No. 90–290
Each . $0.15

No. 90–295
Each . 0.11

No. 90–305
Platinum Tipped
Each . $0.75



No. 90–310
Each . $0.11

No. 90–312
Each . $0.10

No. 90–297
Each . $0.11

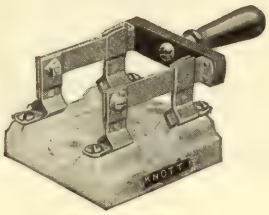
No. 90–299
Each . $0.15

No. 90–315 Triple Connectors . . . . . Each $0.18

BATTERY CARBON BINDING POSTS, see page 422

SWITCHES

No. 90–325



No. 90–330

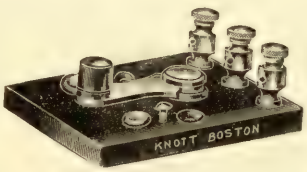
90–325 **SINGLE POLE, SINGLE THROW KNIFE SWITCH,** 15 amperes at 125 volts, mounted on porcelain base **$0.42**

90–327 **SINGLE POLE, DOUBLE THROW KNIFE SWITCH,** 15 amperes at 125 volts, mounted on porcelain base . . . . . **.65**

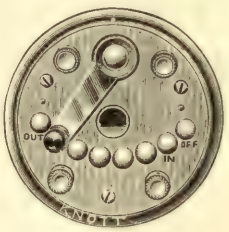
90–330 **DOUBLE POLE, SINGLE THROW KNIFE SWITCH,** 15 amperes at 125 volts, mounted on porcelain base . . . . . **.52**

90–335 **DOUBLE POLE, DOUBLE THROW SWITCH,** capacity 50 amperes at 250 volts, heavy construction for lantern work **2.25**

No. 90–340



No. 90–352



No. 90–365

90–340 **POINT SWITCH,** wood base, brass terminals, one point **$0.16**

90–342 **POINT SWITCH,** wood base, brass terminals, two point . . . . . **.18**

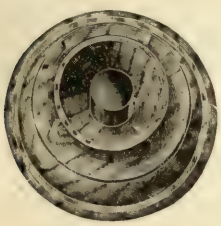
90–350 **ONE-POINT RUBBER BASE SWITCH,** square base, with binding posts on front . . . . . **.60**

90–352 **TWO-POINT RUBBER BASE SWITCH,** square base, with binding posts on front . . . . . **.75**

90–354 **THREE-POINT RUBBER BASE SWITCH,** square base, with binding posts on front **1.00**

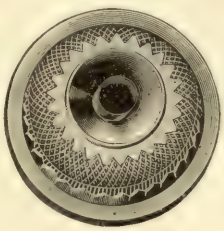
90–356 **FOUR-POINT RUBBER BASE SWITCH,** square base, with binding posts on front **1.20**

90–365 **BATTERY RHEOSTAT AND SWITCH,** suitable for regulating miniature battery lamps, speed of small motors, etc.
This switch consists of six steps mounted on a polished wood base with hard rubber handle. Total resistance 5 ohms; trimmings nickel-plated . . . . . **.95**



No. 90–370

No. 90–375



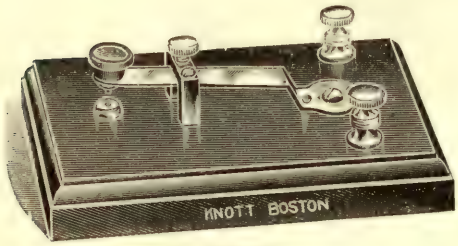
No. 90–380

90–370 **WOOD PUSH BUTTON,** excellent quality, hard rubber button, hardwood antique oak finish . . **$0.10**

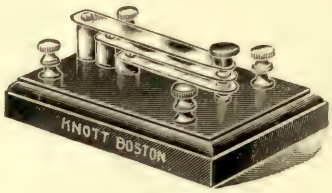
90–375 **DESK PUSH BUTTON,** for $\frac{5}{8}$-inch hole, nickel-plated trim, light pearl button . . . . . Each **.28**

90–380 **METAL PUSH BUTTON,** hard rubber button, ornamented metal case, with screw holes. Diameter $2\frac{3}{8}$ inches . . . . . **.45**

CONTACT KEYS



No. 90–390

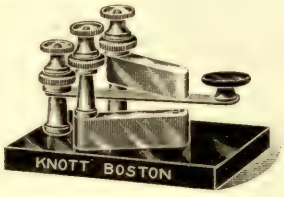


No. 90–392

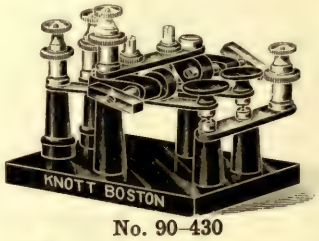
90–390 SINGLE CONTACT KEY, hardwood base, open circuit key with two binding posts **$0.80**
90–392 DOUBLE CONTACT KEY, hardwood base, open circuit with pair of binding posts for each circuit **1.80**

No. 90–410

90–410 HIGH INSULATION DOUBLE CONTACT KEY. This is a high-grade key, especially designed where extra high insulation is required. Heavy ebonite blocks and base, extra large binding posts and heavy platinum contact. All metal parts highly polished and lacquered. This is a handsome and serviceable key for general work **$12.00**

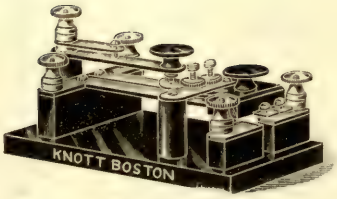


No. 90–415



No. 90–430

No. 90–420



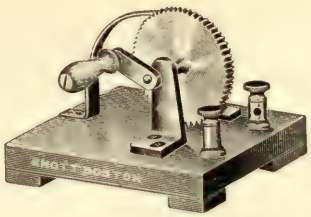
No. 90–425

No. 90–435

The following keys and switches are recommended whenever one has occasion to use high voltages, to make high resistance measurements or accurate tests on condensers or other apparatus.

They are mounted on bases of pure ebonite, and where pillars are used the pillars also are of pure ebonite. Extreme care is used in construction, and our line will be found strictly high grade in every respect. The leakage factor is very low.

90–415 SHORT CIRCUIT KEY **$12.00**
90–420 SINGLE PLUG SWITCH, mounted on ebonite pillars, ebonite handle, spring capped plugs to prevent blocks being forced apart when plug is inserted **16.75**
90–425 LAMBERT'S CAPACITY TEST KEY, heavy ebonite blocks and pillars **22.50**
90–430 RITCHIE REVERSING KEY **24.50**
90–435 KEMPE'S CHARGE AND DISCHARGE KEYS, ebonite handles **20.00**

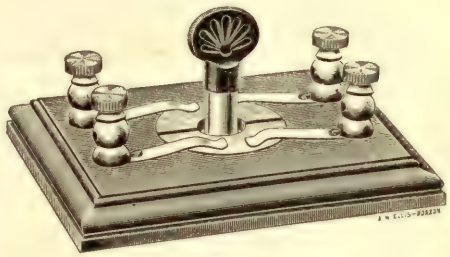


No. 90–460

90–460 INTERRUPTING WHEEL, for interrupting a current.
It is frequently desired in induction experiments to interrupt the current and also to vary the speed of the interruption. The design above illustrated consists of a toothed wheel mounted on an axle attached to the uprights on a neatly polished base. A spring contact arm rests against the toothed rim of the wheel. This spring contact arm is in electrical connection to one binding post and the pillar supporting the wheel to the other. If, therefore, connections are made to the binding posts the current will be interrupted by the teeth of the wheel as it is revolved by means of the crank. These interruptions are positive and the instrument is used to advantage connected in series with the primary of No. **95–40** Primary and Secondary Coil **$2.80**

COMMUTATORS

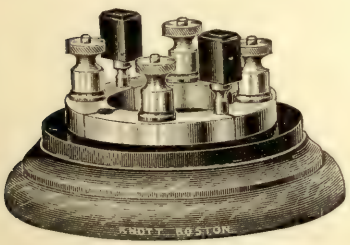
No. 90–470



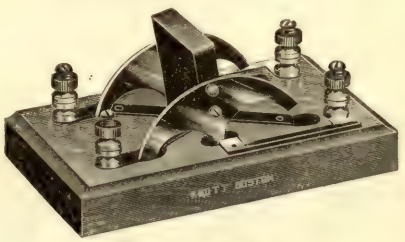
No. 90–475

90–470 SIMPLE MERCURY CONTACT POLE CHANGER. This is a simple standard form with improved mercury wells and contact. Handsomely finished base with four binding posts **$0.65**

90–475 SPLIT RING POLE CHANGER, consisting of a neatly polished wooden base on which are mounted four binding posts with connected contact arms which make contact with the top of the split ring reversing switch.
This switch is provided with a neat key-shaped hard rubber piece. All metal parts neatly polished and lacquered **1.75**



No. 90–480

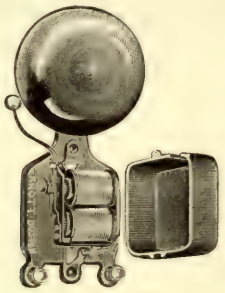


No. 90–485

90–480 PALMER'S PLUG FORM POLE CHANGER. This form consists of a polished base on which are mounted four brass curved blocks, each block provided with a binding post. Current reversal secured by changing the position of the tapered plugs in the tapered holes. Brass parts neatly polished and finished **$2.50**

90–485 IMPROVED BLOCK HANDLE POHL'S COMMUTATOR. The simple form above illustrated secures positive current reversals in a cleanly and efficient manner. The design, originated in our laboratories, consists of a polished wooden base with mercury wells, each well connected to a binding post with a non-detachable top. The pole changer is of the rocking type, securing instant current reversal by merely tipping from one pair of mercury wells to the other. All metal parts are handsomely polished and lacquered **2.40**

ELECTRIC BELLS



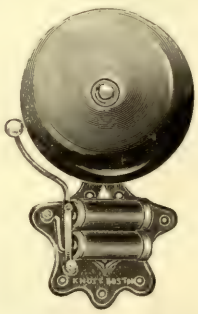
No. 90–525

90–525 **DISSECTIBLE IRON BOX BELL.** This bell is well made, strong, neat and reliable. It will ring satisfactorily with one cell of battery and will not stick or buzz with six cells connected. The cover is of light pressed steel, neatly japanned. The clamps for holding the cover to the frame are ingeniously arranged on the sides by extensions of the plate which holds the armature and magnets. A slight pressure of the fingers on each side of the cover will disengage it from the clamps, opening to view the entire mechanism. Gong 2½ inches in diameter **$0.45**

90–535 **ELECTRIC CALL BELL OUTFIT,** consisting of the above bell with No. **91–300** Dry Cell, No. **90–370** Wood Push Button and about 75 feet of Annunciator Wire **1.00**

90–545 **DISSECTIBLE IRON CLAD BUZZER.** The buzzer listed under this number is in appearance the same as No. **90–525** Bell, without the gong, gong extension and striking rod . . . . . **.45**

No. 90–555



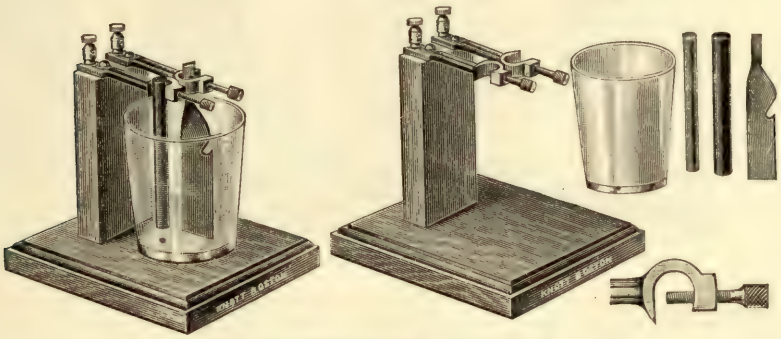
No. 90–565

90–555 **SIX-INCH IRON CLAD WATER-PROOF GONG.** This iron clad bell is designed and constructed to protect the operating mechanism and magnets from dampness, dust, and other outside influences. The case is substantial and is heavily japanned. The end of the striking rod is the only part of the working mechanism not contained inside the case and, as this is operated in a straight line, the opening in the case is very small and securely protected. The contact points are of hardened carbon which permits of the use of a current ranging from 4 to 150 volts with magnets wound for proper resistance. As may be noted from the illustration, the entire dimensions of the bell are confined within the diameter of the gong. The vibrations are strong, rapid, and regular. The materials and workmanship employed in its construction are the best obtainable, and we recommend it as the most satisfactory type for any location where a vibrating bell can be used.
Iron Clad Water-proof Gong, resistance 5 ohms, gong 6 inches in diameter **$6.25**

90–565 **PIVOTED ARMATURE SKELETON BELLS.** These bells are neat and symmetrical in appearance and are guaranteed to give entire satisfaction in any location where a vibrating battery bell will work. The trimmings are all nickel-plated; the contact and binding posts are non-turnable; the gong is of pressed steel, heavily nickel-plated.

	a	b	c	d
Diameter of Gong . .	6	8	10	12 inches
Each	**$2.95**	**4.85**	**7.75**	**11.50**

BATTERIES



GILLEY-SKIDMORE BATTERY

91–10 GILLEY-SKIDMORE BATTERY STAND, for the study of the various phenomena of the voltaic cell. This stand has been used for a number of years and its extensive sale has been sufficient recommendation for it. By reference to our illustration it will be seen that the stand consists essentially of a support to the upright of which are fastened the two arms bearing the clamps. To these arms may be attached various accessories for the study of characteristics of different types of cells and, also, in formulating the laws governing the action and efficiency of a simple single or two-fluid cell. This form of Students' Battery Outfit is recommended, since the wire leads are attached to the binding posts on the top of the stand, which has a broad base and hence avoids the tipping over of the battery which occurs in other types.

This cell is admirably adapted for its purpose and excels in simplicity of construction the much more expensive and bulky commercial cells. In the study of the leading types of batteries various accessories may be used to set up the complete cell. The cell is particularly adapted for the study of polarization, internal resistance, effects of different solutions, etc., and readily adapts itself to the construction of the Electro-motive Series. All parts are neatly finished and the battery presents a pleasing appearance in any laboratory.

Gilley-Skidmore Battery Stand only, without any accessory parts **$1.20**

91–12 GILLEY-SKIDMORE BATTERY STAND, with jar, copper, and zinc element for study of simple single fluid cell **1.40**

91–15 GILLEY-SKIDMORE BATTERY STAND, complete with all the accessories listed below **2.40**

SEPARATE PARTS

91–15a JAR **$0.06**

91–15b POROUS CUP, 3 × 7.5 centimeters inside diameter . . . . . **.12**

91–15c ZINC PENCIL, ⅜ inch diameter . . . . . **.06**

91–15d CARBON PENCIL, ⅜ inch diameter . . . . . **.11**

91–15e ZINC ELEMENT, right angle stem . . . . . **.08**

91–15f COPPER ELEMENT, right angle stem . . . . . **.08**

91–15g IRON ELEMENT, right angle stem . . . . . **.07**

91–15h ALUMINUM ELEMENT, right angle stem . . . . . **.10**

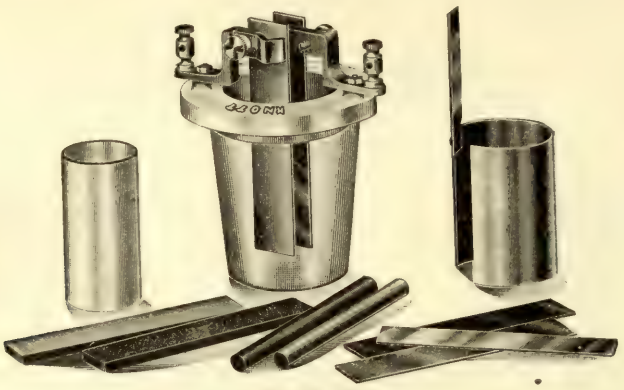
91–15i LEAD ELEMENT, right angle stem . . . . . **.07**

91–15j PURE BLOCK TIN ELEMENT, right angle stem . . . . . **.20**

91–15k COPPER CYLINDRICAL ELEMENT . . . . . **.25**

91–25 TURNER AND HERSEY TAPERING ZINC ELEMENT, for use with above outfit in the study of polarization . . . . . Each **.08**

91–35 "GOTHAM" STUDENTS' CELL. Complete with 8 elements and porous cell **2.75**



No. 91–42

91–40 HALL'S DEMONSTRATION STUDENTS' BATTERY, IMPROVED FORM, as originally designed by the Arthur W. Hall Scientific Co., for the study of the various phenomena of the voltaic cell.

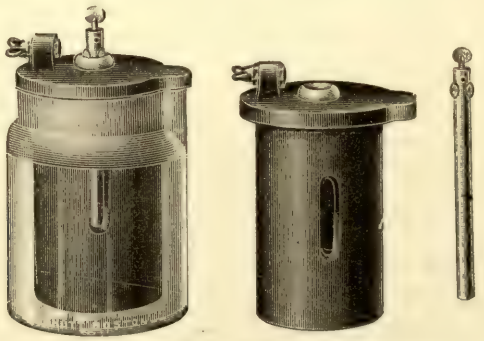
In our new demonstration cell for individual student study we have improved our top by the substitution of a neat porcelain piece moulded to fit the rim of the jar, a great improvement over the old metal top. To this porcelain top are attached the arms which bear the clamps. These clamps are of such form that they will hold either a rod like a zinc or carbon pencil or any flat piece of metal up to one-quarter inch thick. By means of a special swivel arrangement it is possible to vary the distance between the two elements at will, an advantage which becomes apparent at once in experiments on internal resistance. On one of these holders there is a hard rubber projection making it impossible to short circuit the two elements. The connections are such that no amount of corroding will interrupt the circuit as it does in the metal top battery.

Hall's Demonstration Students' Battery, complete for a simple copper and zinc cell, including glass jar **$0.80**

91–42 DEMONSTRATION STUDENTS' BATTERY, complete with all accessories listed below, including special copper cylindrical element **1.70**

ACCESSORIES

91–43	**JAR**	**$0.06**
91–44	**POROUS CUP,** inside measurements 3 × 7.5 centimeters	**.12**
91–45	**ZINC PENCIL**	**.06**
91–46	**CARBON PENCIL**	**.11**
91–47	**ZINC ELEMENT,** flat	**.05**
91–48	**COPPER ELEMENT,** flat	**.05**
91–49	**LEAD ELEMENT,** flat	**.05**
91–50	**IRON ELEMENT,** flat	**.05**
91–51	**ALUMINUM ELEMENT,** flat	**.05**
91–52	**TIN ELEMENT,** flat	**.11**
91–53	**COPPER CYLINDER ELEMENT**	**.25**
91–54	**CARBON ELEMENT,** flat	**.11**

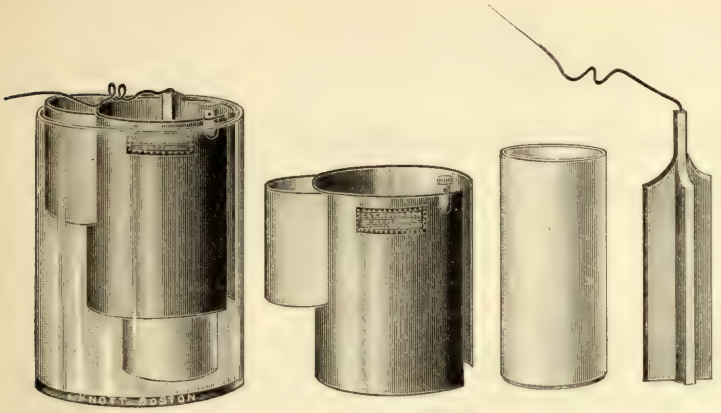


No. 91–65

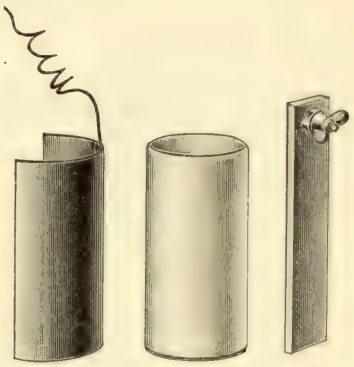
91–65 LECLANCHE BATTERY, especially adapted for " open circuit " work, most frequently used in bell service. E. M. F. about 1.4 volts.

Cell complete **$0.50**

91–67	**POROUS CUP,** sealed	**.32**
91–68	**ZINC PENCIL,** with binding screw	**.05**
91–69	**JAR**	**.17**



No. 91–75



No. 91–90

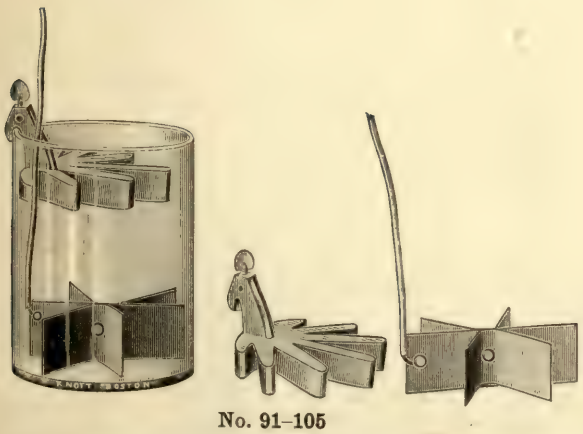
91–75 GALLON STANDARD DANIELL CELL. This cell has attained the position of a standard laboratory cell, being readily adapted to all kinds of circuit work. Its E. M. F. is about 1.08 volts, this voltage remaining constant throughout the life of the cell. For this reason it may be seen that it is of great value for work in electrical experiments.

Cell complete, one gallon size, including Jar and Porous Cup, special Copper Cylinder with holder, and Zinc Element $1.65

31–265c	JAR	.40
91–77	POROUS CUP	.20
91–79	ZINC ELEMENT	.50
91–80	COPPER CYLINDER	.65

91–90 QUART STUDENTS' DANIELL CELL, complete 65

91–92	POROUS CUP, 2 × 4 inches	.15
91–94	ZINC ELEMENT WITH BINDING POST	.20
91–96	COPPER ELEMENT	.11
31–265b	JAR	.25



No. 91–105

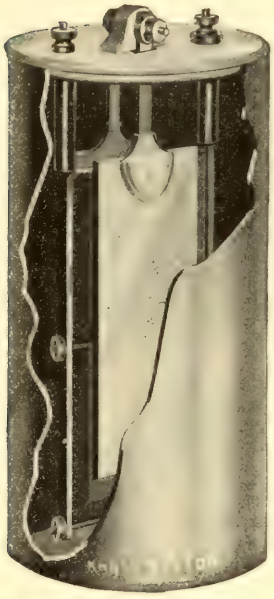
No. 91–120

91–105 CROW FOOT GRAVITY CELL, one of the most popular closed circuit cells, very largely used by telegraph and telephone companies, gallon size, complete $0.95

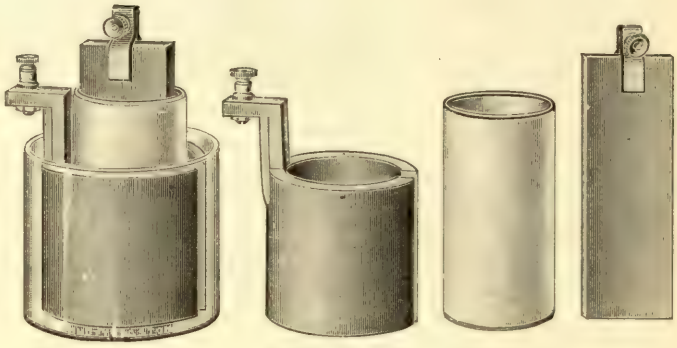
91–107	ZINC ELEMENT, crow foot type	.45
91–110	COPPER ELEMENT	.20
31–265c	JAR	.40

91–120 IMPROVED FULLER CELL, for general laboratory service, open or closed circuits. This cell has unusually high E. M. F., about 2.4 volts, with internal resistance of .4 ohm, gallon size complete . 1.50

91–122	POROUS CUP, 3 × 7 inches	.22
91–124	ZINC ELEMENT	.50
91–135	CARBON CYLINDER	.65
31–265c	JAR, 6 × 8 inches	.40



No. 91–145



No. 91–165

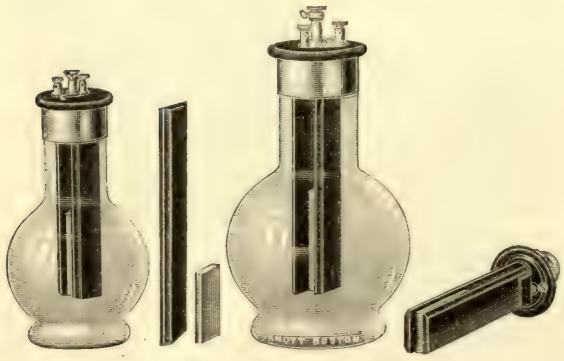
91–145 EDISON BATTERY, for closed circuit work. This type of battery has many features which have made it a popular laboratory cell. It is free from obnoxious fumes, does not polarize readily but has low E. M. F. of only .067 volts. Type "S" (300 ampere-hour capacity) $3.00

91–147	COPPER OXIDE ELEMENT (2 plates)	.62
91–149	ZINC ELEMENT (2 plates)	.50
91–151	CAUSTIC SODA (1 charge)	.28
91–153	HEAVY OIL (1 charge)	.06

91–165 BUNSEN CELL, a two-fluid cell for "open circuit" work. E. M. F. approximately 1.9 volts, internal resistance about 1.8 ohms.

Bunsen Cell complete, one quart size 1.30

31–265b	JAR, 5 × 4 inches	.25
91–167	POROUS CUP, 2 × 4 inches	.15
91–169	ZINC ELEMENT, special shape with binding post	.75
91–170	FLUTED CARBON ELEMENT, with connector and binding post	.20



GRENET BATTERY

91–180 GRENET BATTERY, especially adapted for experimental and demonstrative work. This battery occupies little space and furnishes a powerful current for a short time. E. M. F. is approximately 2 volts at the start with very small internal resistance.

A further advantage of this type of cell is that the zinc element may be raised from the fluid, thus stopping action of the cell, and preserving the strength of the solution.

One-pint size complete $1.65

91–182	ZINC ELEMENT	.15
91–184	CARBON ELEMENT	.20
91–186	JAR	.68

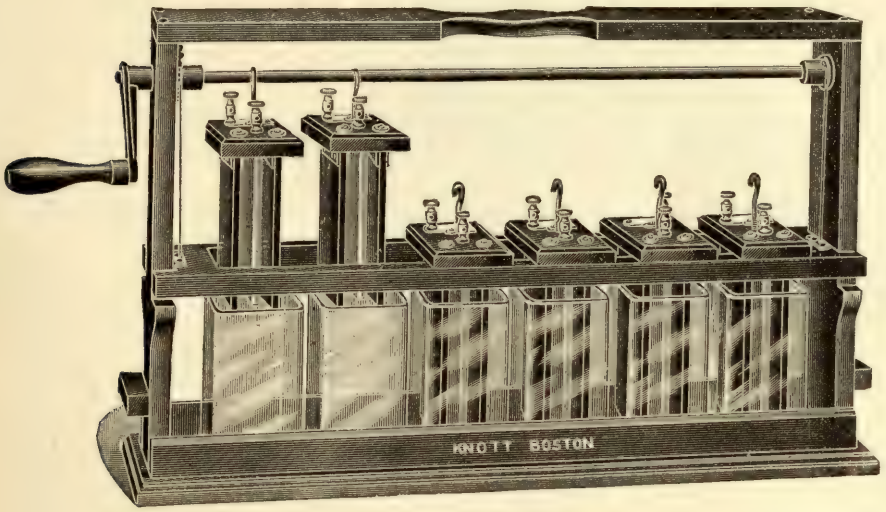
91–190 GRENET BATTERY, similar to above, but one-quart size, complete 2.20

91–192	ZINC ELEMENT	.17
91–194	CARBON ELEMENT	.30
91–196	JAR	.90

91–205 GRENET BATTERY, similar to above, but two-quart size, complete 3.50

91–207	ZINC ELEMENT	.25
91–209	CARBON ELEMENT	.40
91–210	JAR	1.20

PLUNGE BATTERIES



No. 91–225

91–225 SIX-CELL HIGH SCHOOL PLUNGE BATTERY. Perhaps no source of current for lecture table or general laboratory work has become so desirable as that furnished by the Chromic Acid Cell. In the design illustrated above may be noted a form of portable cell which has found great favor throughout the country. Each cell is a unit in itself delivering about 2 volts and very powerful current for a short time. One or more may be combined in series or parallel to give a large E. M. F. or amperage.

The type is arranged so that from one to six may be used as desired. All six may be placed at one time in the solution. If it is desired that only four be used, as above, two may be suspended to the cross rod.

This battery is substantially made, provided with every convenience for safe use, and will be found indispensable when once used.

Complete as illustrated, arranged for six cells $18.00

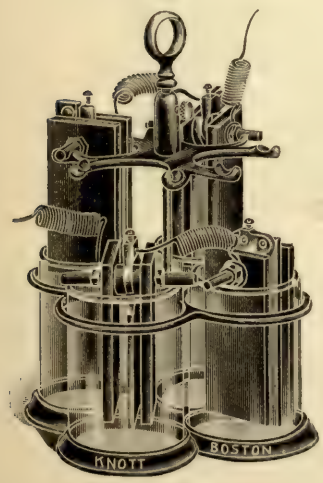
91–227 FOUR-CELL SCHOOL PLUNGE BATTERY, same as above, but arranged for four cells 13.50

91–229 COMPLETE ELEMENT, including top, two carbon, and zinc elements 2.00

91–231 CARBON ELEMENT 25

91–233 ZINC ELEMENT 37

91–235 SQUARE BATTERY JAR 35



No. 91–245

91–245 FOUR-CELL STUDENTS' PLUNGE BATTERY. This is a simple combination of Chromic Acid Cells provided with adjusting features which permit of lifting one or more cells from the solutions. It may be used to advantage on the demonstration table, but has been designed particularly for students' experiments.

Complete as illustrated, four-cell type $5.00

91–247 TWO-CELL STUDENTS' PLUNGE BATTERY, similar to above, but arranged for two cells only 3.00

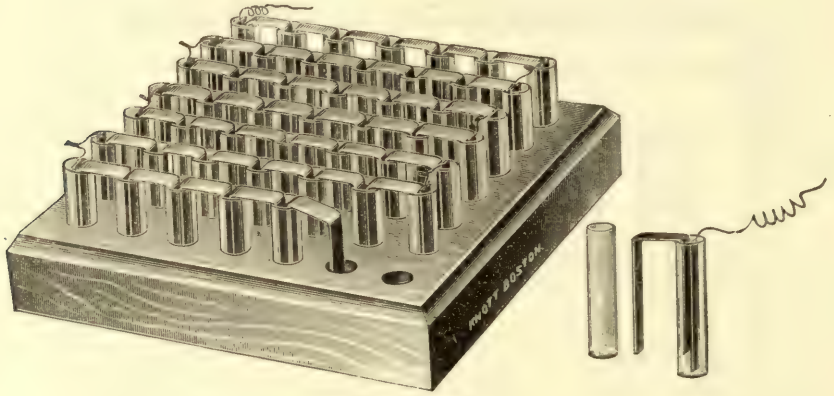
91–250 COMPLETE ELEMENT, including two carbons and one zinc element with all connections 1.00

91–252 CARBON ELEMENT 20

91–254 ZINC ELEMENT 20

31–265a SPECIAL BATTERY JAR 12

WATER BATTERIES



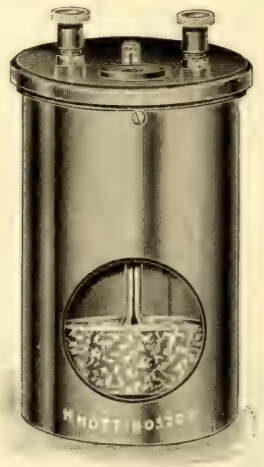
No. 91–265

91–265 **WATER BATTERY,** 50 cells, mounted on substantial neatly finished wooden base. This battery is particularly adapted to advanced work when high voltage and low amperage are desired. It will be found a most serviceable battery for all electrostatic and electrometer work . **$6.25**

91–267 ——, same as above, but comprising 100 cells. This battery is a combination of two of the above **12.75**

STANDARD CELLS

No. 91–280

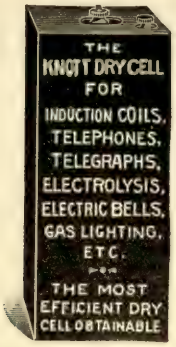


No. 91–284

91–280 **MOUNTED H-FORM STANDARD CELL.** This cell is furnished appropriately mounted on base provided with binding posts. It is designed that students may assemble their own cells. Complete as illustrated **$1.75**

91–282 **H-FORM STANDARD CELL,** same as above but unmounted, glass part only with sealed-in platinum electrodes **1.25**

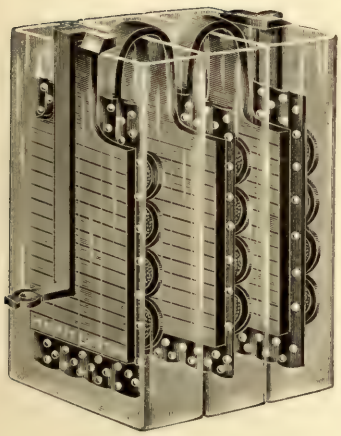
91–284 **CLARK'S STANDARD CELL.** This cell attains an E. M. F. almost instantly. It has a temperature coefficient of only .038% per degree. It is furnished in a brass case with ebonite top, binding posts with ebonite caps, and is provided with a certified thermometer. With certificate of accuracy by Physikalischen Technische Reichsanstalt . . . . . Duty Free **12.50**



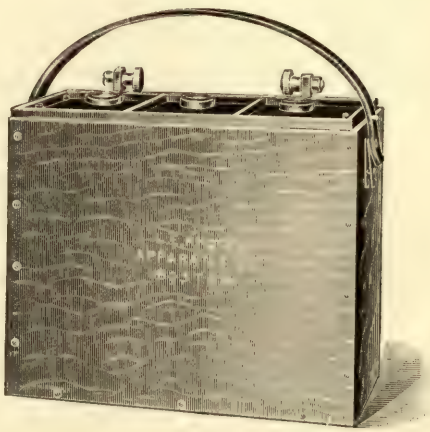
No. 91–300

91–300 **DRY CELL.** In our seventeen years' experience we have experimented with a great number of dry cells. For length of life, high electro-motive force, and low internal resistance we believe that the cell illustrated above is unexcelled. It polarizes slowly and recovers rapidly. We have no hesitancy in recommending its use for general laboratory work . . . . . Each **$0.25**

STORAGE BATTERIES



Nos. 91–325 to 91–330



Nos. 91–335 to 91–350

91–325 **STORAGE BATTERY, LEAD-LEAD TYPE.** The plates measure 3¼ inches square, and the glass jar is 6½ inches high. The cell has a capacity of six ampere hours at an E. M. F. of two volts . . **$1.50**

91–330 ——, same as above, but a much larger cell, and is recommended for such work as operating Ruhmkorff coils, performing electrolysis experiments, and other laboratory work where a heavy current is necessary. The lead plates measure 7¾ inches square and are contained in a glass jar 11¾ inches high × 9 inches wide × 3½ inches deep. The capacity of each cell is 36 ampere hours at an E. M. F. of two volts. **5.50**

We recommend either three or four cells as the proper laboratory outfit.

91–335 **PORTABLE STORAGE BATTERY,** enclosed in wooden case as shown in the illustration. Capacity 60 ampere hours at an E. M. F. of six volts **19.25**

91–340 ——, same as above, capacity 80 ampere hours at an E. M. F. of six volts **24.75**

91–345 ——, same as above, capacity 100 ampere hours at an E. M. F. of six volts **28.00**

91–350 ——, same as above, capacity 80 ampere hours at an E. M. F. of eight volts **31.00**

BATTERY SUPPLIES

31–265 BATTERY JARS, of excellent quality.

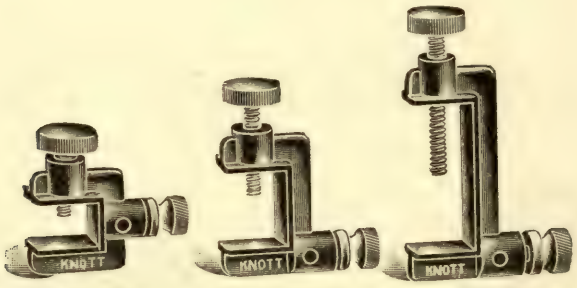
	a	b	c	d
Size, inches	2¼ × 3¼	4 × 5	6 × 8	8 × 12
Each	**$0.12**	**.25**	**.40**	**1.50**

91–380 RECTANGULAR BATTERY JARS, of excellent quality.

	a	b
Size, inches	2½ × 4¼ × 7	4 × 4 × 8
Each	**$0.30**	**.35**

91–395 CARBON ELEMENTS.

	a	b	c	d	e	f	g
Length, inches	5	5½	7 1/16	8⅝	3¼	6	6¼
Width, inches	⅞	1¼	1 9/16	2	1½	3½	1
Thickness, inch	3/16	¼	5/16	⅜	¼	¼	¼
Each	**$0.11**	**.20**	**.30**	**.40**	**.20**	**.25**	**.22**



No. 91–410a No. 91–410b No. 91–410c

91–410 CARBON AND ZINC BATTERY CONNECTORS.

	a	b	c
For plates	¼ to ⅜	⅜ to ¾	¾ to 1¼ inches
Each	**$0.20**	**.35**	**.65**

THE IMPROVED RAPID BATTERY CONNECTORS

As will be suggested from the cut (see page 407), these battery connectors are made of a carefully proportioned spiral spring of phosphor-bronze wire, the proper size to give sufficient rigidity and at the same time to make them easy of connection.

The spirals being separated by a slight pull, the straight end of the next connector is readily slipped in place, making a secure and constant electric contact which will not accidentally loosen in the course of the experiment.

These terminals are especially serviceable in laboratory work, since they have the important feature of being connected with equal facility to either an English or American form binding post. For parallel or multiple connection they are equally well suited. The use of this connector, therefore, does away with the multiplicity of connectors designed for meeting the conditions of various kinds of binding posts. It frequently happens that one type of instrument having an English post has to be connected with another having an American post. With the usual form of connectors this condition is very hard to meet. With the " Rapid " this difficulty is entirely overcome.

Please note the diagram for methods of connecting to English posts, to American posts, and for connecting in multiple and parallel circuits.

As will be noted from the listing below, these connectors are furnished in pairs or in quantity, without wire connections, also furnished with wire connections of varying length.

90–175 THE IMPROVED RAPID CONNECTING TIPS . . . . . Per Dozen **$0.25**
Per Hundred **2.00**

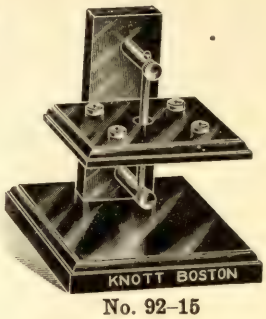
90–177 THE IMPROVED RAPID CONNECTORS, attached to connecting cords 6 inches long, especially designed for close connections, such as joining batteries in multiple and in series . . . Per Pair **.20**

90–179 THE IMPROVED RAPID CONNECTORS, attached to connecting cords 2 feet long . . Per Pair **.30**

90–180 THE IMPROVED RAPID CONNECTORS, attached to connecting cords 3 feet long . . Per Pair **.40**

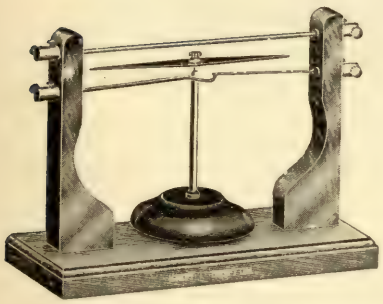
ELECTRO-MAGNETISM

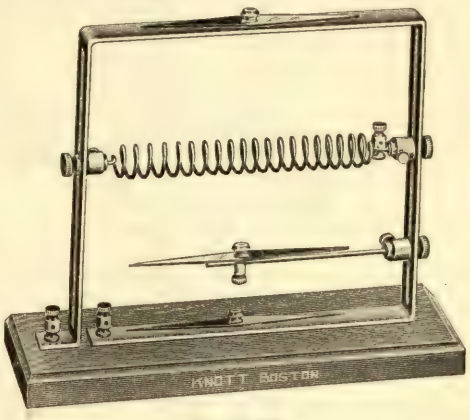
92–15 AMPERE'S LAW STAND, a convenient stand with clamp for holding a No. 10 copper conducting rod; with shelf for arranging small compasses about the conductor and binding posts for connecting the lead wires.
This apparatus was designed to use in the study of the lines of force about a current bearing conductor. Full directions for the experiment will be found in the National Physics Direction Sheets, experiment E041, a copy of which will be furnished with each instrument. A most direct way of determining Ampere's Law **$2.00**



No. 92–15

OERSTED'S LAW APPARATUS


No. 92–20



No. 92–30

92–20 OERSTED'S LAW APPARATUS, for study of magnetic action of currents and formulating Ampere's rule.
This apparatus consists of a base to which are mounted two pillars, each provided with two binding posts, one each for the terminals of the parallel conducting wires. A sensitive magnetic needle separately mounted on a base of its own is readily adjusted so that its point of support comes midway between the parallel wires. This mounted magnetic needle is our No. **81–12** and will not be required if already a part of the equipment **$2.85**

92–22 OERSTED'S LAW APPARATUS FRAME, only without mounted magnetic needle **2.25**

81–12 MOUNTED MAGNETIC NEEDLE, as used in No. **92–20** . . . . . **.60**

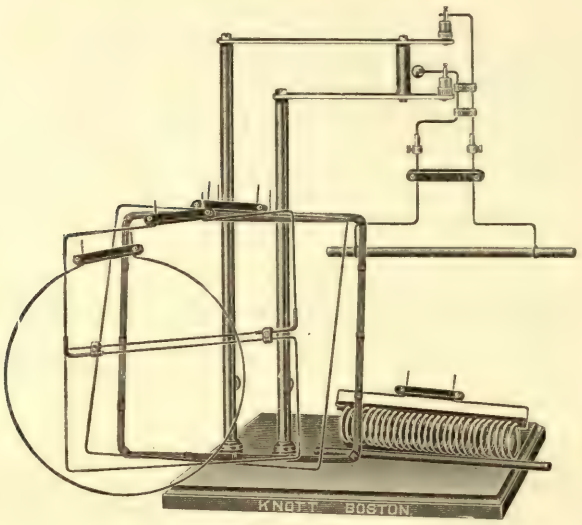
92–30 HELIX OERSTED'S LAW APPARATUS, for a study of the directive action which a fixed current exerts at a distance on a magnetic needle, and for formulating Ampere's Rule. This, our **adjustable needle** and **adjustable helix design,** consists of a rectangular metal frame mounted as illustrated on a polished wooden base. The upright parallel sides of this frame are slotted to carry the holders for the movable needle and for the helix. That a study of the effect of a current through a helix on a magnetic needle may be noted, the holders of the helix are provided with a pair of binding posts, one on each end. A pair of binding posts is also furnished for connecting a current to the rectangular frame. Two fixed needles, one over the upper part of the frame and one within the frame over the under side, and a movable needle which may be fixed in any position within the frame indicate the directive action of a current on a magnetic needle.
All metal parts of this apparatus are finely polished and lacquered and the needles are delicately balanced on steel pivot points.
Complete as illustrated, with three needles and helix attachment **6.40**

92–35 SIMPLE ADJUSTABLE NEEDLE OERSTED'S LAW APPARATUS. This design is essentially the same as illustrated and described above. It is, however, furnished without the helix attachment and without the two fixed needles. As may be readily noted, by means of this movable needle, the holder movable in height and the needle movable along the holder, practically any position within and, if desired, outside the frame may be secured **4.00**

92–37 HELIX ATTACHMENT, for attachment to above frame in study of the directive action of a current through a helix upon a magnetic needle.
This attachment is provided with clamps for instant clamping to the slotted upright parallel sides of the frame **1.50**

92–40 BAR OF IRON and BAR OF WOOD, for placing within helix attachment above for a study of the magnetic effects produced . . . . . Per Pair **.30**

AMPERE'S LAW



No. 92–50

92–50 AMPERE'S FRAME, illustrating various phenomena due to the magnetic effects of an electric current. The design, improved in many ways incapable of illustration, consists essentially of a base to which are mounted two metal uprights. At the tops of these uprights are attached arms carrying at their extremities two steel cups for mercury in which are placed the pivoting points of an improved suspension device carefully balanced by means of a metal ball and provided with sockets and binding screws for attaching the different contact frames.

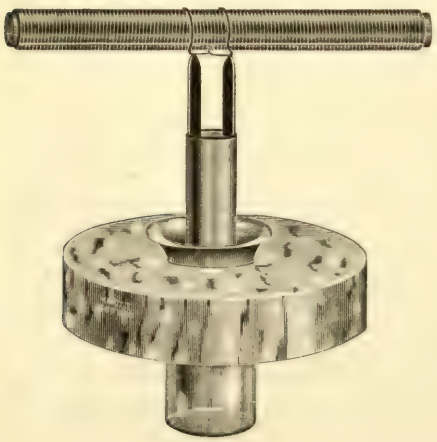
These frames are designed to illustrate in a satisfactory manner several interesting and instructive phenomena, each frame interchangeable in the suspension device. Five frames are furnished, — a loop, a rectangle, an astatic rectangle, a rectangular coil, and a solenoid. In addition there are furnished a suspension frame for a bar magnet and a soft iron rod.

Perhaps no single piece of apparatus designed for the study of magnetism has such wide application as does this time-honored Ampere's frame. Results are strikingly illustrated with the minimum of annoyance. In our design we have endeavored to obviate the previous sources of difficulty in the old forms and are enabled by our many improvements to guarantee satisfactory results.

The design is capable of demonstrating in a positive manner:

1. Mutual Action of Magnets and Solenoids.
2. Action of Currents on Solenoids.
3. Directive Action of the Earth on Solenoids.
4. Directive Action of Magnets on Currents.
5. " Sucking Effects " of Solenoids.
6. Action of a Current on a Pivoted Magnet.

Apparatus complete as illustrated, including all accessories described above **$11.00**



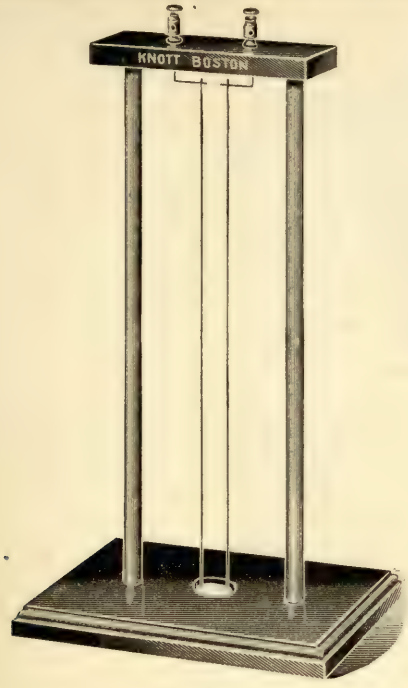
No. 92–60

92–60 FLOATING HELIX AND CELL, for demonstrating the magnetic polarity of an electro-magnetic solenoid.

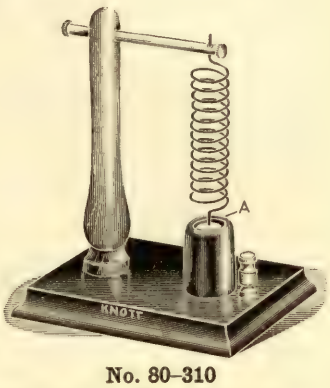
This apparatus consists of a small cell, the leads of which are formed into a horizontal solenoid. In use the elements are placed into the small jar held in a disc of cork, and the whole placed in a jar of water where the combination will float upright. The solenoid will soon take a position so that the axes will point true North and South. From further tests with a bar magnet it will be noted that the solenoid will act the same as a magnetic needle, one end developing South and the other North polarity.

Cell complete as illustrated **$1.60**

PARALLEL CURRENT APPARATUS



No. 80–305



No. 80–310

80–305 PARALLEL CURRENT APPARATUS, for illustrating mutual actions of parallel currents. The design consists of an insulated stand to the head of which are attached binding posts in electrical connections with two bent copper wires. To these bent wires are suspended two small straight copper rods cut to the proper length, which will allow their free ends to extend within the mercury well set in the base.

In use it is always best to amalgamate the ends of these copper rods. Success of the experiment depends also upon allowing the rods to just make contact with the surface of the mercury. Parallel currents flowing in the same direction may be secured by connecting both binding posts with one pole of the battery; the other pole should be connected to a binding post (not shown in illustration) fastened to the base and in electrical connection with the mercury well.

Parallel currents running in opposite directions may be obtained by simply connecting the battery terminals and the binding posts, at the top.

In the first case, repulsion of the wires will be noted; in the second, attraction $1.70

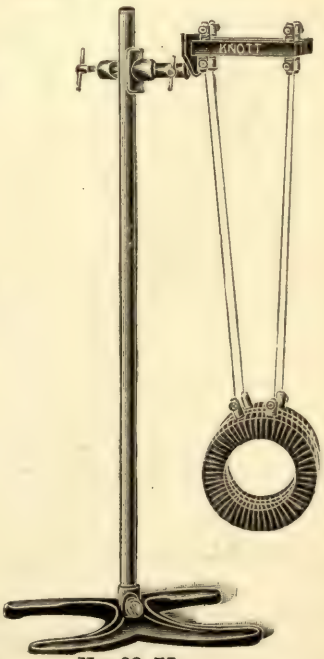
80–310 CONTRACTING HELIX, illustrating the mutual action of currents. This apparatus consists of a spiral of copper wire, one end of which is suspended from a rigid arm, the other end free to dip into a well of mercury located in the base. If current is allowed to flow through the spiral, attraction between the convolutions causes the coil to contract, and the end to be lifted out of the cup of mercury, thus breaking the circuit when current and attraction cease, and the wire dips again into the mercury. A rapid and vibratory motion, therefore, is produced $2.15

92–75 PARALLEL CURRENT REPULSION COILS with **BIFILAR SUSPENSION,** designed to teach the mutual influence of parallel currents and self-induction. One of the coils when used separately is well adapted for experiments on the Earth Magnetic Field.

The apparatus consists of two carefully constructed form-wound coils of 1000 turns double cotton covered copper wire. Each coil is taped, shellaced and baked. Provided with binding posts for bifilar suspension.

As the illustration indicates, the coils are suspended by an adjustable clamp fitting a vertical rod of from 13 to 19 millimeters in diameter, the clamp being so designed that the distance between the coils may be varied at will. Connections to the coils from the clamp are such that they are readily joined either in multiple or in series according to the current available. The coils are wound for resistance to take 110 volt direct current when running in series.

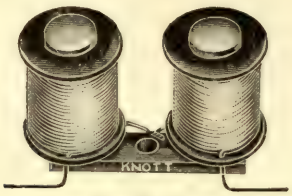
Price complete without stand 7.75



No. 92–75

NOTE. When one of these coils is used for experiments in Earth Induction, we recommend the use of our Lecture Table Galvanometer No. 93–130.

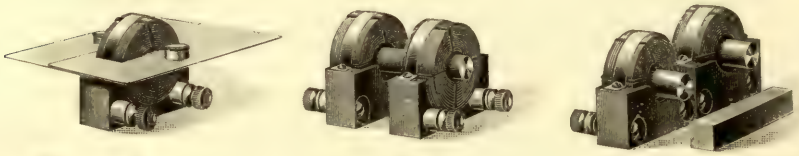
ELECTRO-MAGNETS



No. 92–100

92–100 STUDENTS' ELECTRO-MAGNET, simple electro-magnet capable of complete demonstration of magnetic induction **$0.50**

Figs. 1 2 3 4 5 6



Figs. 7 8 9

Nos. 92–110 to 92–130

92–110 GILLEY INDUCTION COILS, mounted with binding posts.

These coils are designed for students' use in the study of Induction and Electro-magnetism. Carefully prepared students' directions for their use will be found in the Turner and Hersey series of experiments, E042, E150 and E153. Copies of these experiment sheets are furnished with each pair of coils.

As the illustration indicates, the coils are form-wound, shellaced and baked so as to make a rigid unit and mounted on a conveniently designed wood base with binding posts, the form of the base being such as to permit the greatest freedom of use in the experiments for which they are intended. The hole in the center is of the correct size to take the soft iron armature in the study of electro-magnets. Sold by the pair only . . . . . Per Pair **$1.40**

ACCESSORY APPARATUS FOR THE STUDY OF INDUCTION AND ELECTRO-MAGNETS USING THE GILLEY COILS

Each of the items listed and illustrated in Figures **2**, **3**, **4**, **5** and **7**, are designed for use with the Gilley Coils in performing experiments outlined in the National Loose-Leaf Sheets above referred to.

92–115 SOFT IRON U-SHAPED CORE, Fig. **3**, for study of bipolar electro-magnets . . . . . Each **$0.20**

92–117 SOFT IRON ARMATURE, Fig. **2**, for use with the above core in the study of electro-magnets, Each **.10**

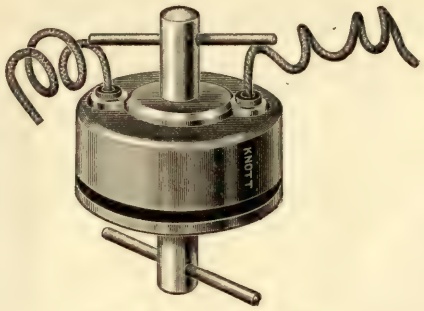
92–120 SOFT IRON CORE, Fig. **5**, single, for the study of electro-magnets . . . . . Each **.10**

92–122 PAIR OF HALF-ROUND CORE PIECES, Fig. **4**, for mapping the lines of force in an electro-magnet. Per Pair **.15**

92–125 PAIR OF SLOTTED CARDBOARDS, Fig. **7**, for mapping lines of force . . . . . Per Pair **.08**

Figures **8** and **9** in the illustration show how the above apparatus is used in the study of the Simple Transformer, Induced Currents and Electro-Magnet.

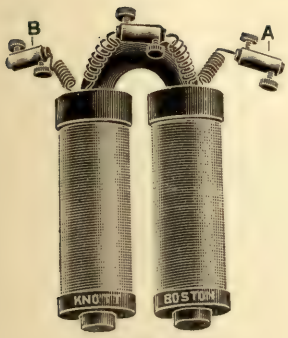
92–130 COMPLETE GILLEY INDUCTION OUTFIT, supplied in box, with direction sheets **$2.00**



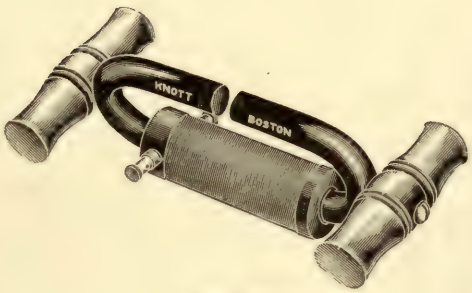
Nos. 92–150 to 92–152

92–150 INSTITUTE IRON CLAD MAGNET, 300 lbs. capacity. In the design above illustrated we have greatly improved the structure by conforming to the scientific requirements. The shell cross sectional area in our model is equal to that of the core. We therefore secure a more intense uniform magnetic field, as may readily be demonstrated by testing with iron filings. By conforming, therefore, to scientific requirements we secure a greater lifting power than is found on a number of similar instruments on the market.
The instrument is neatly finished and heavy leads are provided for connection to battery supply. . **$4.50**

92–152 INSTITUTE IRON CLAD MAGNET, 100 lbs. capacity. Same as above, but smaller in size **2.25**



No. 92–160



No. 92–175

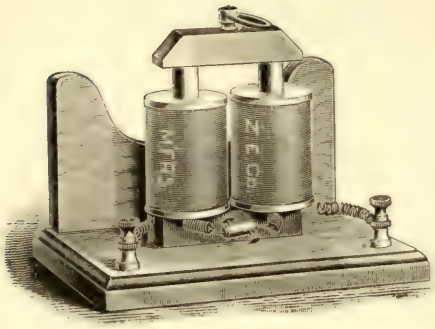
No. 92–185

92–160 SIX-INCH DEMONSTRATION ELECTRO-MAGNET, detachable Helices, soft iron U-shaped core with 6-inch arms. Helices 4½ inches long provided as illustrated with double connectors . **$2.35**

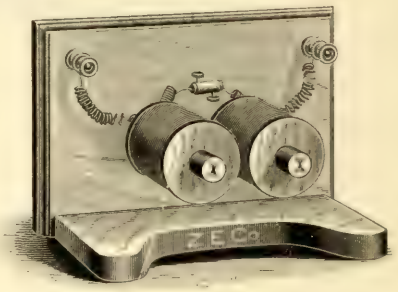
92–165 FOUR AND ONE-HALF HELIX ELECTRO-MAGNET. New York State form **1.35**

92–175 HELIX AND SEPARABLE MAGNETIC CIRCUIT (HELIX AND RING), for demonstrating magnetization by current.
This apparatus consists of two symmetrical U-shaped soft iron rods each with a handle. A detachable form-wound helix is fastened to one branch of one of these U-shaped pieces so that when the ends of the U's are placed together to form a closed magnetic circuit half of the helix will cover one of the branches of one of the U's and half of the corresponding branch of the other U.
Before battery is connected no magnetism is noticeable, but as soon as current is allowed to pass through the helix considerable force is needed to separate the U's.
Complete as illustrated **2.90**

92–185 SOLENOID MAGNET, for illustrating the principle of a solenoid magnet.
This apparatus consists of a glass tube closed at one end and on which is fastened a helix of wire. If now a bar of soft iron is placed so that it rests on the closed end and the helix is connected to source of current supply, the "sucking" effect of the magnetic force is immediately demonstrated.
Complete as illustrated with soft iron rod **1.70**



Upright Position



Horizontal Position

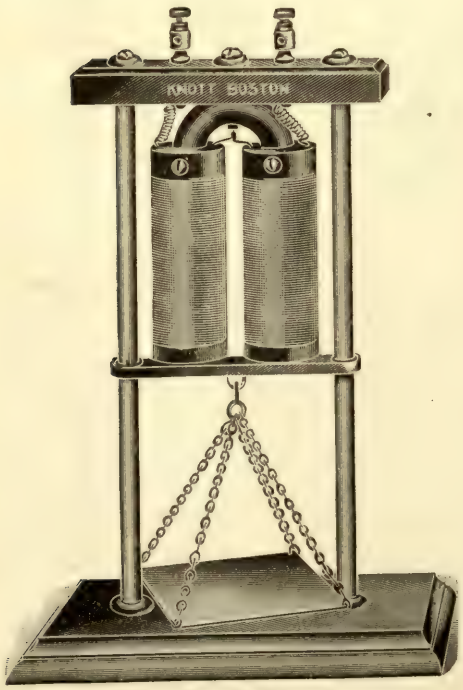
No. 92–195

92–195 IMPROVED MOUNTED ELECTRO-MAGNET, useful as a demonstration electro-magnet; also for remagnetizing. In this design mounted for use in the two positions above illustrated we offer not only a design capable of electro-magnetic study but also one inferior to none in appearance and utility.

This apparatus consists of two 6-inch U-shaped soft iron cores to the branches of which are attached two removable helices. This combination is mounted on a neatly finished support designed for use of the electro-magnet in two positions. Binding posts are provided for connections to battery. Actual tests give the sustaining power of this instrument of from 150 to 200 pounds.

Electro-magnet mounted as illustrated **$7.50**

92–197 ELECTRO-MAGNET, same as above, but unmounted **5.50**

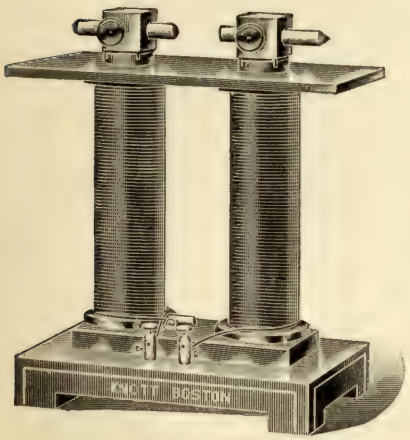


No. 92–200

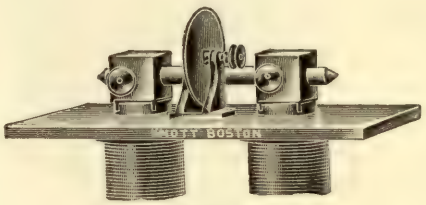
92–200 ONE-HUNDRED-TEN-VOLT LIFTING MAGNET, for demonstrating the lifting power of an electro-magnet.

This is a substantial, neatly finished instrument designed on ample lines for use on demonstration desk. It consists of a supporting frame at the top of which is attached the electro-magnet. For quantitatively measuring the magnetic pull, a scale pan is attached to the armature. A stop is provided so that the pan with weights cannot fall to the base at breaking point. By repeated tests on 2 amp., 100 v. it has been demonstrated that this electro-magnet will sustain about 150 pounds. Its use will give to the student a clear conception of great lifting power, demonstrating to him its ready adaptation to commercial electro-magnet hoists **$8.80**

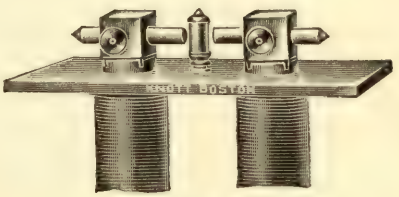
PARAMAGNETIC AND DIAMAGNETIC STUDY APPARATUS



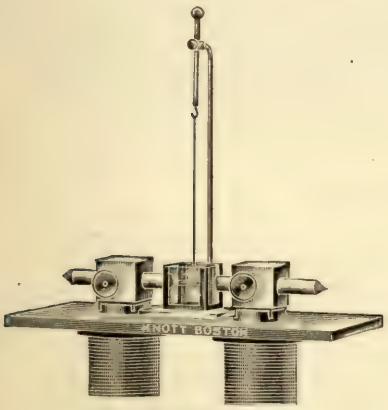
No. 92–215



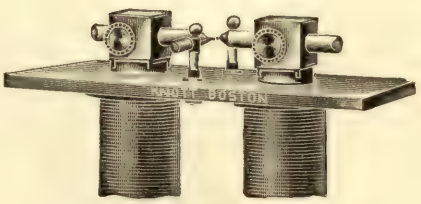
No. 92–215 (Fig. 2)



No. 92–215 (Fig. 3)



No. 92–215 (Fig. 1)



No. 92–215 (Fig. 4)

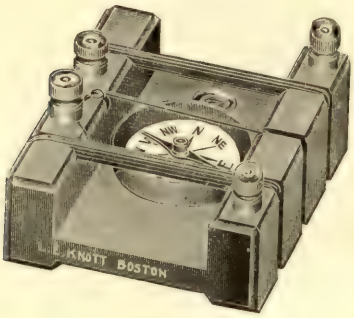
92–215 PARAMAGNETIC and **DIAMAGNETIC STUDY APPARATUS,** for general electro-magnetic study but especially designed for study of Paramagnetism and Diamagnetism. This magnet is sufficiently powerful for all school purposes, yet not too bulky for ready handling. The iron core measures 31 centimeters in length by 5.5 centimeters in diameter, and other parts are in proportion. It is mounted on substantial base and furnished with pole pieces and pole changer as illustrated. With each electro-magnet are furnished the following accessories: —

1. **Mounted Copper Disc** illustrating retarding and stopping of rotation due to the current set up in the disc.
2. **Mounted Copper Cylinder** illustrating the heating effects in a magnetic field, demonstrated by the boiling of ether placed in the cylinder.
3. **Mounted Cubical Vessel** and **Suspension System** for illustrating Diamagnetism and Paramagnetism, including ten different metal rods, — lead, silver, bismuth, nickel, copper, iron, zinc, tin, aluminum, and antimony, each with a small hook for suspension. In using the metals on suspension support the hollow cube is not necessary, as this cube is used to show the magnetization of ferric chloride solution.
4. **Insulation Points** with binding screws for illustrating diamagnetism of flames and the deflection of the auriole of electric discharges.

Apparatus complete with all accessories as above listed . . . . . Duty Free **$68.00**

ELECTRICAL MEASURING INSTRUMENTS

GALVANOSCOPES

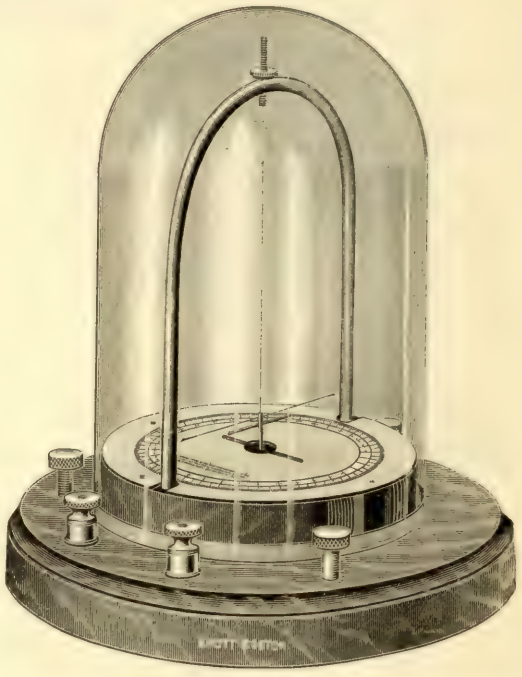


No. 93–10

93–10 GALVANOSCOPE, after Millikan & Gale's "A Laboratory Course in Physics," pp. 80 to 100.

This instrument has three separate circuits, each with two binding posts for connections. One circuit is wound with twenty-five turns of No. 22 wire, another with one hundred turns of fine wire, and another with a single turn of coarse wire. Thus it may be seen that the sensibility of the instrument can be changed at will depending upon the number of turns used in circuit as well as on the position of the compass relative to the current bearing coil.

Complete as illustrated with compass **$1.65**

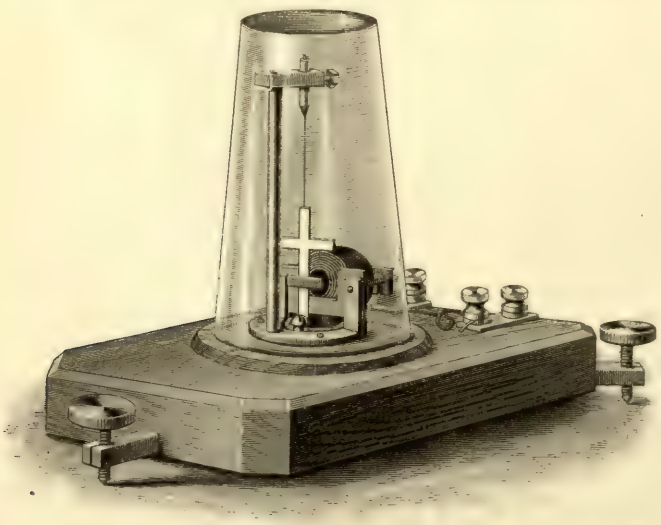


No. 93–20

93–12 GALVANOSCOPE FRAME, as illustrated above but without compass **$1.40**

ASTATIC GALVANOMETERS

93–20 ASTATIC GALVANOMETER. This instrument was designed according to the requirements of the National Physics Course, built on the close-coil type, with astatic system in which one needle moves between the coils and one above. Aluminum dial 3½ inches, windings of No. 18 copper wire, resistance approximately one ohm. The instrument is provided with three leveling screws and binding posts. A convenient and sensitive instrument where low voltage only is to be used **$3.75**

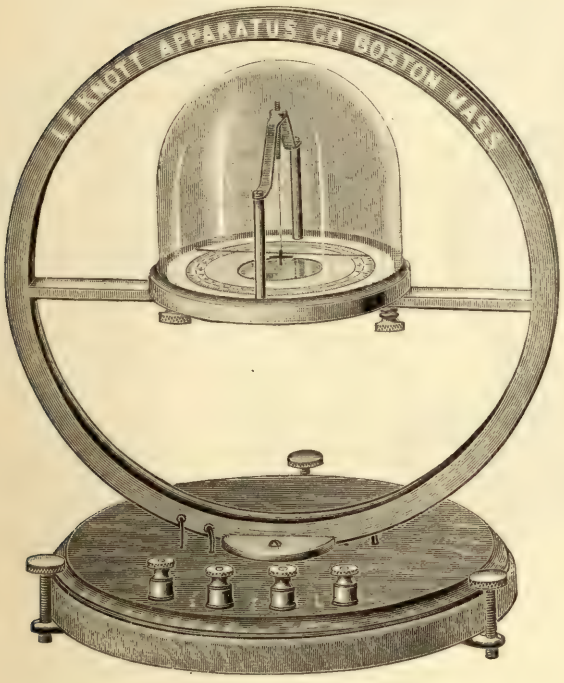


No. 93–30

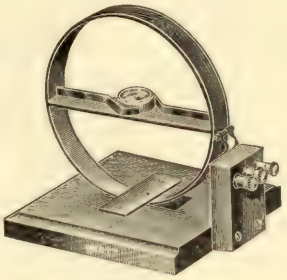
93–30 TROWBRIDGE SENSITIVE GALVANOMETER. This instrument is constructed on the close-coil principle in which the magnet is suspended from a light aluminum vane hanging in front of the coil. Coils of varying resistances may be supplied if desired. The coil with which the instrument is furnished is intended for Wheatstone Bridge work and other experiments where the voltage is exceedingly low. The end of the aluminum vane projects into a metal cup under the coil which, for purposes of making the instrument dead-beat, may be filled with glycerine, if desired. The actuating coil is clamped in metal clips and may be easily removed.

This instrument has the advantage over the conventional form of Astatic Galvanometer since all the parts are clearly exposed. The instrument is more nearly dead-beat and by use of an outside control magnet, for which the instrument is well adapted, a great variation in sensibility is obtained **4.25**

TANGENT GALVANOMETERS



No. 93–60



Nos. 93–40 to 93–50

93–40 THE SIX-INCH TANGENT GALVANOMETER (or GALVANOSCOPE), a Tangent Galvanometer of simple construction, coil of oxidized brass 6 inches in diameter, arranged with binding-posts which connect to 5, 10, and 15 turns respectively of No. 18 wire. Please note that all connections are exposed so that the student can very easily trace the direction of the current. This is an important feature in students' work. The compass used may be of varying sizes, brass or jewel bearing, any size of compass being held in the exact center of the coil by means of our double acting spring clips. With the short needle compass the instrument naturally conforms more nearly to the requirements of the Laws of Tangents.

This is a convenient instrument for such experiments as Tracing the Lines of Magnetic Force, rough experiments in Measurement by Substitution, and a large number of general experiments such as ordinarily given in the first year science courses. The educational value of this form of instrument we consider far greater than the cheap close-coil instruments sometimes offered. With brass-capped compass $2.20

93–44 STUDENTS' SIX-INCH TANGENT GALVANOMETER, with agate-bearing compass 3.00

93–50 STUDENTS' SIX-INCH TANGENT GALVANOMETER, with large compass and pointer 3.65

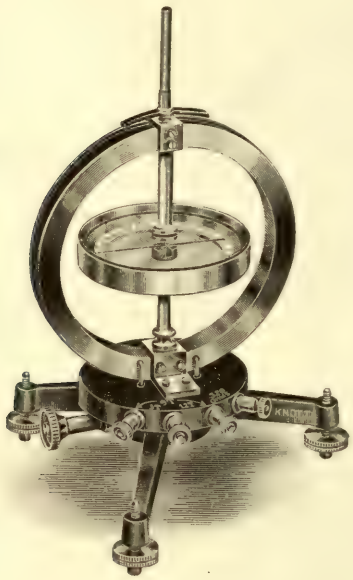
THE HARCOURT TWENTY-TWO CENTIMETER TANGENT GALVANOMETER

This Galvanometer is designed for High School use. It has all of the essentials of the higher-priced instruments. It is of substantial construction but without unnecessary finish.

We employ an aluminum ring 22 centimeters in diameter which, with a 2-centimeter magnet, enables the laws of the Tangent Galvanometer to be definitely determined. The coil is 6 millimeters wide, so that errors resulting from this source are reduced to a minimum. Provided with leveling screws and compass box 11 centimeters in diameter, mirror dial and glass dome. This compass box is easily removable by loosening two set screws shown on the cross bar. With the compass box removed the instrument is readily made use of in a variety of experiments on induction. The instrument is provided with four binding posts connecting consecutively to 5, 10, and 15 turns of wire.

93–60 THE HARCOURT TWENTY-TWO CENTIMETER TANGENT GALVANOMETER, with fiber suspended needle and long aluminum pointer and mirror dial $7.15

93–65 THE HARCOURT TWENTY-TWO CENTIMETER TANGENT GALVANOMETER, with jewel-bearing magnet and long aluminum pointer in place of the fiber suspension 7.15



No. 93–75

93–75 STANDARD TANGENT GALVANOMETER. This is a distinctly higher grade instrument than the preceding. All parts have been made with the greatest care. As will be noted from our illustration, it is provided with a Thompson adjustable control magnet with both a vertical and horizontal motion. It slides on a post in a carefully adjustable sleeve. A coil 13 millimeters wide is mounted on a finished brass ring 20 centimeters in diameter. This ring is mounted on a substantial base to the binding posts of which are carried the terminals of the coil.

The suspension system consists of a needle 15 millimeters long, suspended by fiber and provided with a convenient and satisfactory lift. The needle is protected by a box 12½ centimeters in diameter, provided with silvered engine-divided dial.

To meet the conditions of the greatest variety of experiments in practical laboratory work and also for determining the constant in a tangent galvanometer the windings have been carefully worked out as follows: —

3 turns of coarse wire connected to posts 1 and 2, wound clock-wise.

12 turns of coarse wire connected to posts 2 and 3, wound counter clock-wise, giving between posts 2 and 3, nine turns of coarse wire wound counter clock-wise.

320 turns of fine wire connected to posts 1 and 4, wound clock-wise. This coil is especially designed for determining the constant of a tangent galvanometer.

We have no hesitancy in claiming that this is one of the most carefully designed and scientifically proportioned galvanometers on the market **$33.00**

93–80 ——, same as above, but mounted on polished hardwood base in place of the tripod **22.50**

D'ARSONVAL GALVANOMETERS

The enormous increase in the use of electric current and the employment of iron in the construction of buildings make necessary the use of a type of measuring instrument which is not affected by outside magnetic influences. Of the different types devised the only one which survives by its general fitness is the Deprez-D'Arsonval, usually called the D'Arsonval Galvanometer, but which was first used by Thompson in his work on the Atlantic cable.

So free is this instrument from magnetic influences that it can be used close to large dynamos and motors. Owing to the method of suspension, the powerful magnetic moment exerted by its moving coil, and the great restoring force of the suspension, it is singularly free from the effects of vibration as compared with the older types of instruments. In short, a well-designed D'Arsonval Galvanometer is almost the ideal instrument for indicating and measuring electric currents in laboratories devoted to either educational work or to technical research.

Development in the D'Arsonval Galvanometer construction has made such rapid progress that exceedingly sensitive instruments, if correctly designed, are now practical for placing in the students' hands.

As will be noted from the illustrations on the following pages, we use the D'Arsonval principle on instruments designed both for lecture table demonstration and for students' individual laboratory work.

MEASURE OF SENSIBILITY. In the rating of all of our galvanometers we use the "megohm standard," recognized by the best European manufacturers as the one which conveys most intelligibly the information the user should have at hand.

MAGNET SYSTEM. Wherever practical we use the laminated magnet for the reason that it gives not only greater magnetic pull per unit area, but more particularly because of its ability to hold its magnetic strength with less loss from rough usage. It will also be noted that we use the closed circuit magnet because of its well-recognized quality of greater strength and permanency. This form of magnet has not heretofore been largely used because of the greater expense involved in properly magnetizing it. The ampere turn method which we use has been recognized as the only reliable one for magnetizing a magnet designed for use in galvanometer work. The expense, however, involved in this method, particularly in the closed circuit type of magnet, is such as heretofore to have discouraged many manufacturers from using this type of magnet.

SUSPENSION SYSTEM. We have designed a form of suspension system which is used in practically all of our D'Arsonval type of instruments, both lecture table and students' type, In this form the entire suspension system can very easily be removed from the magnets, placed on the table in an easily accessible position for the ready interchange of suspension. This will be found of convenience at times, notwithstanding the fact that the liability of breakage of the suspension has been greatly reduced. We supply suspension ribbons and coils with connecting strips which can be attached almost instantly without the aid of either a screw driver or soldering copper.

COILS. All coils, unless otherwise specified, are of the dead-beat form, but for Capacity and Induction work we supply, when ordered, coils especially adapted to this work for either type of instrument.

METHOD OF READING. The method of reading employed is such in every case as is best adapted to the particular type of instrument and the use to which it is to be put. On the various types we use the several different systems as here specified:

A POINTER, reading on either the vertical or horizontal scale.

MIRROR READING, employing the back target fiducial mark, making it possible to use a front opening wide enough for both eyes to be used in their normal position without errors of parallax.

THE MIRROR METHOD with the small peek hole front target, designed more particularly for advanced students.

TELESCOPE READING. All of our instruments, except the inexpensive students' type No. **93–200,** are supplied with mirrors. The regular reading device may be very easily removed and the instrument used as a telescope reading instrument.

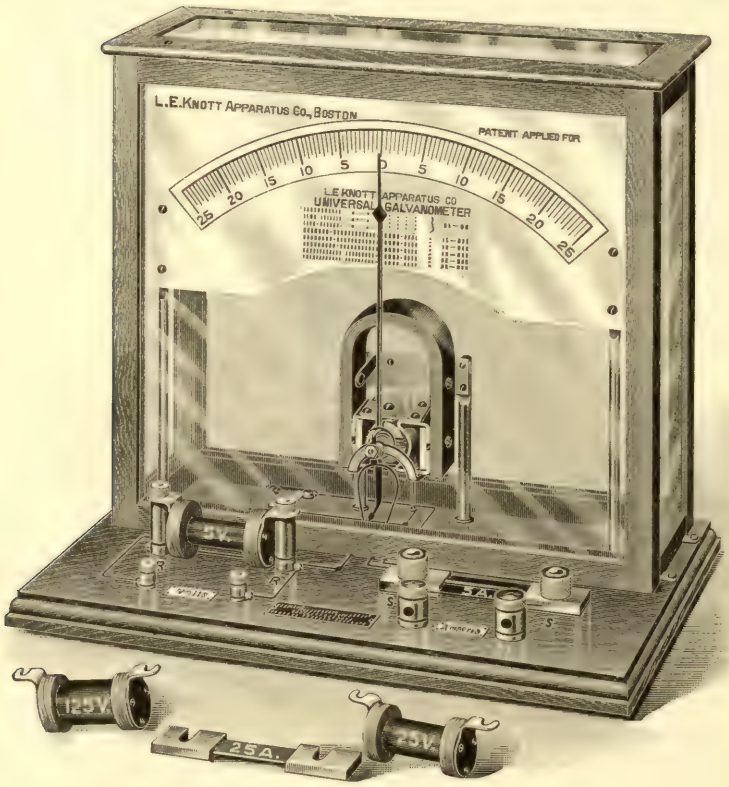
THE TELESCOPE MOUNTING and **BRACKET,** illustrated under No. **93–245,** is designed of such size as to take any of our standard type of instruments.

LECTURE TABLE GALVANOMETERS

No. 93–130

UNIVERSAL LECTURE TABLE GALVANOMETER

EIGHT INSTRUMENTS IN ONE



Patent Pending

Designed for a practical and reliable Lecture Table instrument covering a **wide range** and giving one division deflection on .002 of a volt.

The movement is of the commercial D'Arsonval type but slightly modified; the moving coil adjusted for one ohm resistance, making it possible to supply at any time detachable and interchangeable shunts or resistances of any desired range.

EIGHT INSTRUMENTS IN ONE

The following eight instruments are therefore available in this one outfit:

1. **A Galvanometer** in which one space deflection means .002 of an ampere or .002 of a volt.
2. **A Millivoltmeter** in which the entire scale deflection means 25 millivolts in ½ millivolt divisions.
3. **A Milliamperemeter** in which the entire scale deflection means 25 milliamperes in ½ milliampere divisions.
4. **A Voltmeter** range of 0–5 volts in 1/10 volt divisions.
5. **A Voltmeter** range of 0–25 volts in ½ volt divisions.
6. **A Voltmeter** range of 0–125 volts in 2½ volt divisions.
7. **An Amperemeter** range of 0–5 amperes in 1/10 ampere divisions.
8. **An Amperemeter** range of 0–25 amperes in ½ ampere divisions.

DIAL. The dial is **twelve inches long** with wide and clearly indicated divisions. Note below the reproduction of the scale about ⅛ size. It may easily be read in any part of the lecture room.

FOR THE INSTRUCTOR'S CONVENIENCE the back of the dial carries a scale with full and explicit directions for connecting. On the base is a protecting switch to avoid accidentally burning out the coil by a mis-connection.

A NEW METHOD OF CONNECTING SHUNTS, which automatically insures the same contact pressure on both the shunt and coil circuit. This eliminates all liability of contact error in the shunt system.

UNIVERSAL FEATURES. We have produced an instrument in which both the educational and commercial features have been carefully considered and economically solved.

ACCURACY. The calibration is done in connection with the best standard commercial instruments. All parts are carefully constructed. The magnets are aged by the standard aging method. The jewel bearings are best quality sapphire. In short, we believe this instrument to be the best electrically, mechanically, and educationally, that has ever been offered.

93–130 UNIVERSAL LECTURE TABLE GALVANOMETER, complete with full set of Shunts and Resistances giving ranges previously listed **$35.00**

EXTRA SHUNTS AND RESISTANCES. Should an instrument of any other range than that already provided for be desired, the proper shunts and resistances will be furnished on special order at the net price each of **2.50**

L. E. KNOTT APPARATUS COMPANY,
HARCOURT STREET,
BOSTON, MASS.

GENTLEMEN, — Let me add that your Galvanometer has been a most thoroughly satisfactory instrument and wonderfully sensitive.

Very sincerely yours,
(Signed) HAROLD B. REED,
Instructor in Physics,
East High School,
Cleveland, Ohio.

February 21, 1912.

GENTLEMEN, — Your Lecture Table Galvanometer has been a great help in teaching the subject of current electricity to mixed classes. The fact that all connections and moving parts are plainly in view, and the scale large and open, and the ranges large make it an ideal educational instrument.

The use of the ammeter shunts and of the switch shunt and their effects on the deflection of the needle, tend to clear up the subject of divided circuits.

I have it before my classes during our study of current electricity and use it constantly. It is a usable and extremely satisfactory instrument and one that should be in every Physics lecture room.

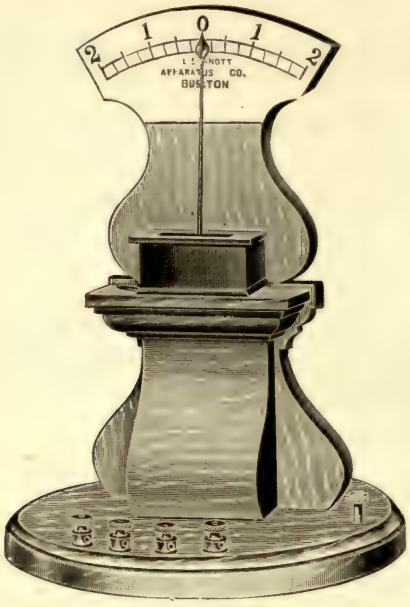
Very truly,
(Signed) ERNEST R. SMITH,
North High School,
Syracuse, N. Y.

March 15, 1912.

GENTLEMEN, — The Lecture Table Galvanometer has been received and in good condition. Needless to say I am much pleased with it and will make excellent use of it. In fact, it is just about the device I have been looking for and it is probable that I shall order a second unit of this kind for our laboratory, next year.

Very truly yours,
(Signed) WILLIAM H. BROWNE, JR.,
N. C. Coll. of Agriculture & Mechanic Arts,
West Raleigh, N. C.

March 28, 1912.

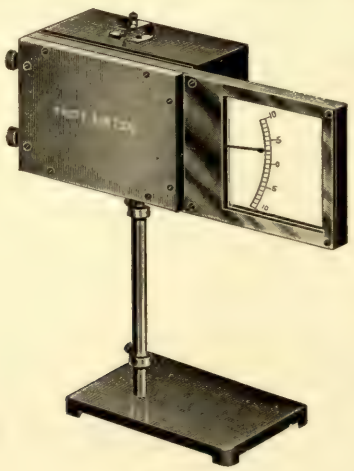


No. 93–145

93–145 LECTURE TABLE GALVANOMETER. As will be noted from the cut, this instrument is mounted vertically, of sufficient height for lecture table use. The scale is large and open so as to be seen across the lecture room, the pointer of aluminum, the bearings jewel, the moving system a 1½-inch magnet. The windings are in three sections, — coarse, medium, and fine wire of varying resistances and varying ranges.

This is not designed for an instrument of high sensibility, but rather to cover the widest range feasible to attain in an inexpensive lecture table instrument.

It will be found well adapted for such experiments as polarization, the study of the relative strength of cells either in groups or in multiple, experiments on induction taken in the larger way, and many other experiments which will suggest themselves as adapted to this range of instrument **$6.50**



No. 93–155

93–155 THE LAMPRA PROJECTION GALVANOMETER. This galvanometer is of the same general type as used in France and Germany in the early days of the pivotal bearing D'Arsonval. It has, however, been greatly improved by taking advantage of more recent developments in galvanometer construction.

As will be noted from the illustration, it is especially adapted for projection work, the scale chamber being of the regulation slide holder size with glass both sides of the indicator. The galvanometer movement is encased in a compact box mounted so as to give adequate adjustment for any form of Projection Lantern, the indicator moving over an arbitrary scale. The entire instrument, including the indicator chamber, is sealed for proper protection against dust and air currents. A most effective and convenient demonstration instrument for lantern work **$22.00**

No. 93–175

THE IMPROVED LAMINATED MAGNET

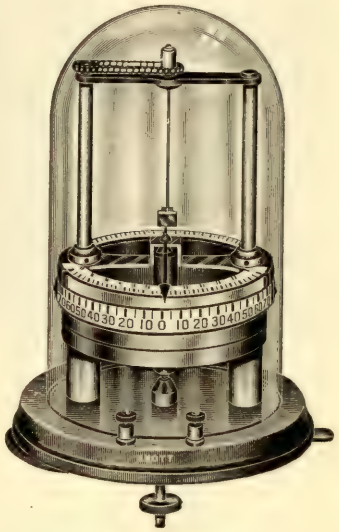
LECTURE TABLE GALVANOMETER

30 MEGOHM SENSIBILITY

MAGNETS. As the illustration shows, this instrument is made up of four horizontal closed-circuit magnets. Because of the form of the magnet, and the fact that the whole system is laminated, we are able to produce a magnetic pole of a strength at least five times that used in any other Lecture Table Galvanometer on the market.

COIL. We have employed the cylindrical, close-wound coil recognized by instrument makers the world over as being the only form in which the deflections bear the proper relation to the current strength. The value of such a coil in a Lecture Table Galvanometer is of especial consideration, as both the lecturer and the students are able to recognize, from the amount of deflection, the relative amperage passing through the coil.

SCALE. Our instrument is designed for a 60 degree deflection either side of zero, making a total of 120 degrees. Note, also, that the instrument is provided with four scales and double pointer. A vertical scale on both sides of the instrument with coarse divisions, is especially intended for students' readings. A horizontal finely divided scale on top of the magnet on both front and back is of value to the instructor or students desiring to make closer readings than can easily be made on the coarse scale intended for wide range work.



No. 93–175
Patent Pending

NON-PARALLAX READING DEVICE. As will be noted from the illustration, the vertical scale is offset in such a way that the large triangular pointer does not over-lap the scale, but is in the same line with it, making it possible to use the so-called " straight line method of reading," which avoids all errors of parallax.

ZERO ADJUSTMENT. A convenient and most desirable method of adjusting the pointer to zero has been worked out, using the chain and sprocket, one sprocket being mounted on the upper end of the vertical shaft passing down the inside of the supporting post. On the other end of this shaft is a milled-edge disc projecting slightly beyond the base to the left in a most convenient and accessible position. With this arrangement the needle is quickly and easily adjusted to zero without raising the glass dome.

COIL LIFT. For safety in shipping and in handling, the coil is easily raised from the suspension ribbon by a lever conveniently located on the base, on the right of the instrument.

METHOD OF ATTACHING SUSPENSION RIBBONS. In D'Arsonval Galvanometers, using the steel or phosphor-bronze ribbon, there is some danger of breaking the suspension, owing to carelessness in handling the instrument before the coil is raised to shipping position. As will be noted in the diagram, the upper portion of the coil terminates in a horizontal, close-wound spiral between the turns of which the suspension plate is inserted. Should, therefore, breakage accidentally occur, we can furnish a new ribbon with the suspension plates attached, which the customer can insert quickly and easily without the use of a screw driver or soldering copper. This feature makes this lecture table instrument, as well as our complete line of D'Arsonval Galvanometers, practical for use by the most inexperienced.

SENSIBILITY. We have thought it best to adjust this galvanometer to a considerably higher sensibility than is ordinarily furnished for lecture table work, as it permits an entirely new field of experiments not possible with the instruments usually supplied. In case, however, it is desired to reduce the sensibility, this can be very easily done by inserting a coil in the form of a shunt. Special coils for this work will be supplied if desired. While it is perfectly feasible, with our methods of construction, to put out an instrument of very much higher sensibility, it has seemed to us that 30 megohms would meet the greatest variety of conditions. This instrument, therefore, will be adjusted to approximately this sensibility.

THE IMPROVED LAMINATED MAGNET LECTURE TABLE GALVANOMETER, complete as above illustrated **$15.00**

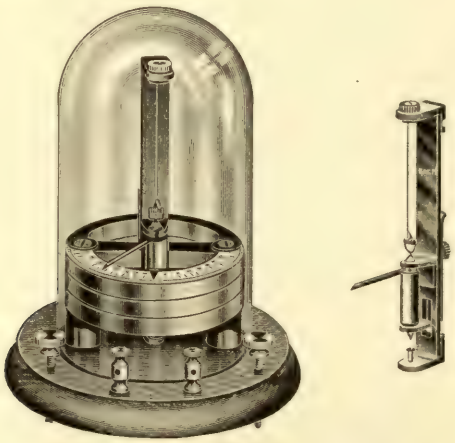
LABORATORY D'ARSONVAL GALVANOMETERS

No. 93–195

93–195 HORIZONTAL GALVANOMETER, D'Arsonval movement, jewel bearing, 0 center. This is a commercial type of instrument in horizontal or laboratory form. The range is such as to make it of the greatest value in general laboratory practice. Quick action, quick reading, adapted to a wide range of experiments, such as Induction, Polarization of Cells, Measurements of the Wheatstone Bridge, where an accuracy equal to ½ millimeter on the bridge is considered sufficient.

Owing to the form of the pole pieces the scale is proportional to the amount of current going through, thus giving the instrument a range of usefulness far greater than its sensibility would indicate.

Jewel bearing, mahogany base, aluminum case. A substantial, convenient, well-constructed instrument of the D'Arsonval type **$7.50**



No. 93–200
Patent Pending

93–200 THE TRIPLE LAMINATED MAGNET GALVANOMETER, students' type, designed by us for use with Millikan & Gale's " A Laboratory Course in Physics."

The simplicity of construction and ease of use in a students' laboratory galvanometer are quite as essential as sensibility. In the instrument above illustrated, simplicity and ease of operation are obtained to an extent which a few years ago was considered impossible. The simplicity of this design will appeal to the practical laboratory instructor. Its sensibility is well within the range which such instruments are designed to meet.

Features. The triple laminated magnet gives greater magnetic pull, enabling heavier ribbon suspensions to be used, thus decreasing the liability of breakage.

As will be noted, the **coil** is of the close-wound type, the same as employed in our Galvanometer No. **93–210,** a form of peculiar value in an instrument designed for individual laboratory work, as the student should be able to determine from the amount of deflection, the approximate voltage and amperage to which the instrument is subjected.

The entire **suspension system** may be removed by loosening a single screw. Should the suspension ribbon be accidentally broken, a new one may be readily inserted in a few seconds by the student. No soldering copper or screw driver is required.

The **zero adjustment** is readily made by turning the metal button at the top of the suspension post.

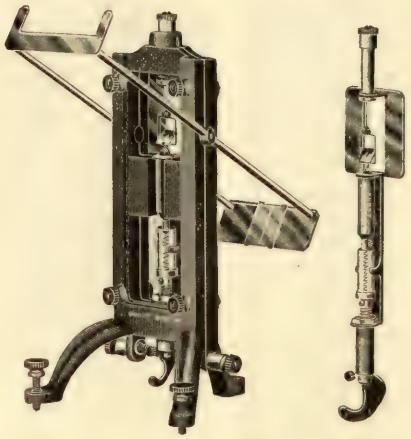
A most efficient **coil lift** is provided which raises the coil from its suspension and clamps it rigidly in position, ready for rough handling and for shipping.

For convenience the **readings** are taken by a pointer moving over a 3½-inch horizontal dial graduated in degrees.

Sensibility. The rating, according to the standard method, is five megohms, although the construction of the instrument is such as to permit of a higher sensibility should it be deemed desirable to use such in the work for which this instrument was designed.

Complete **$3.90**

93–210 THE LAMINATED VERTICAL MAGNET GALVANOMETER. A laboratory galvanometer designed with special reference to the needs of the individual student will be fully appreciated. It has been our purpose to construct an instrument which can be easily set up, adjusted and kept in adjustment and one in which all working parts are constantly in view.



No. 93–210
Patent Pending

The **unit suspension system** which has been worked out according to the lines noted in the detailed illustration carries the coil, upper and lower suspension, zero adjustment and lift, all constituting a single unit attached to the back brass plate. In setting up the instrument this plate is held rigidly between the magnets by means of four screws, removing the thumb nuts from which removes the entire system for inserting Ballistic Coils, coils of high or low resistance, or for replacing broken suspensions.

Our **suspensions** are supplied with metal terminals which are easily slipped between the convolutions of the phosphor-bronze spiral with which the coil is supplied, insuring a perfect electrical and mechanical contact. The lower suspension, which has heretofore been replaceable only by a person with much experience, is now even more easily handled than the upper suspension, as each spiral is sent out contained in a sealed glass tube, the terminals passing through the upper and lower ends of the tube. After the coil is set in place and the adjustment made, the seal is cut away; the galvanometer is then ready to use, all without touching the spiral with either tools or fingers.

We have used on this instrument the modified form of the **reading device** used on our original students' D'Arsonval Galvanometer with the very important modification that the user now looks in an inclined position, permitting the galvanometer to be used on the surface of the table and avoiding the necessity of either getting down to the level of the mirror, or of raising the galvanometer to the height of the eye.

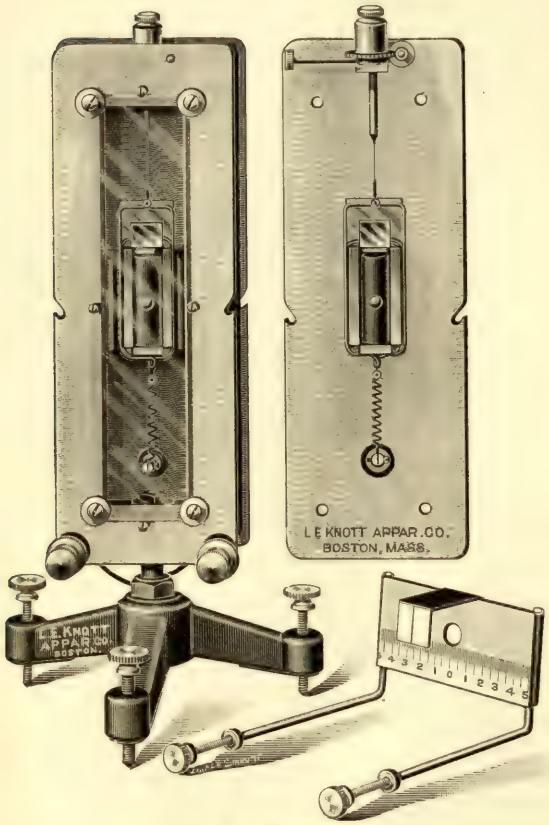
The **sensibility** of this instrument is equal to all requirements for laboratory work. As ordinarily sent out, these instruments are adjusted for 80 megohms sensibility. A higher sensibility than this is readily obtainable if there be adequate demand for it.

POINTS OF ADVANTAGE

The unit suspension system.
The visibility of all parts.
The readiness of assembling and adjustment.
The ease of replacing broken suspensions.
The magnetic strength and permeability due to the laminated magnet.
A method of reading which is practical in the hands of the most inexperienced.
The zero adjustment which is effective and easily handled.
The coil lift, conveniently located and instantly operated by a single movement.
A sensibility of 80 megohms, being substantially four times that obtained in any other students' type of instrument **$7.75**

93–215 BALLISTIC COIL. The above instrument, No. **93–210**, is especially adapted for the use of Ballistic Coils in Capacity and Self-Induction experiments. The most convenient method of inserting the coils is to obtain a unit suspension system with the Ballistic Coil attached. The new system can then be inserted very easily.

Unit Ballistic System complete ready for attaching **7.00**



No. 93–220

93–220 D'ARSONVAL GALVANOMETER, an instrument of high sensibility for use with either scale or telescope reading.

The method of suspending the coil system will be found of the greatest practical value; the entire system may be taken out by loosening the set screws and removing the back plate, as noted in the illustration. Broken suspensions may be very easily replaced by means of a screw driver and repair kit supplied with each instrument.

SENSIBILITY. These instruments are approximately 200 megohms sensibility, of quick movement and practically dead-beat.

METHOD OF READING. The method of reading is effective, overcoming errors of parallax. The reading scale may be easily removed by loosening two thumb nuts. The instrument is then well adapted for telescope reading. When it is desired to use this as a wall form instrument for telescope reading, we recommend telescope, scale, mounting and bracket. (See Index) **$12.00**

93–230 SELF-LEVELING D'ARSONVAL GALVANOMETER, 400 megohms sensibility, either wall or table type (see illustration next page). A galvanometer for advanced laboratory work which is both self-centering and self-leveling, used either as a wall or table instrument. The entire instrument is hung from universal gimbals so that both magnet and coil are always in correct relation.

As a wall instrument. This has a great advantage in overcoming the difficulties usually encountered in fastening an instrument to the wall and securing the proper level.

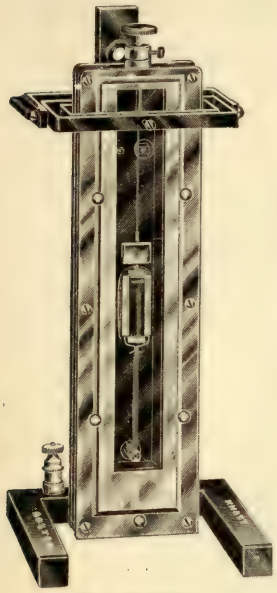
As a table instrument. The advantages are even more pronounced, as the self-centering permits absolute freedom of movement from one portion of the table to another, with assurance that the instrument will instantly assume a level and be ready for use.

Telescope mounting and bracket. The supporting stand for the galvanometer was designed to fit our Universal Galvanometer and Telescope Support No. **93–240.** When the two instruments are used together, a most convenient and effective galvanometer outfit is obtained.

Reading Device. A two-color scale mounted in a sliding socket for adjusting to zero, telescope on an adjustable arm with leveling screws which may be removed when not in use.

The Achromatic Telescope, especially designed for galvanometer work.

Magnet System. By our method of magnet construction we secure far greater strength and permanency than are obtained in any other galvanometer magnet on the market. The concentration of the lines of force to meet the size and form of the coil has been the subject of much careful study.



No. 93–230

Coil System. A removable coil system insures easy access to all delicate parts and the ready replacement of broken suspensions. Extra coil systems designed for special work supplied on request.

Sensibility. As ordinarily furnished, the instrument is supplied with a coil of 600 ohms resistance, giving a sensibility of 400 megohms, the range which has met with the greatest favor.

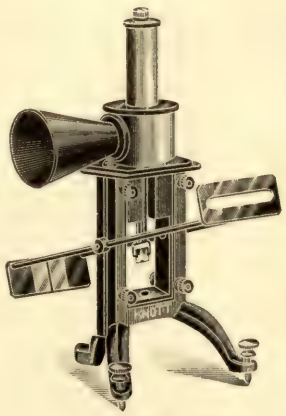
The Mirror is optically plane, $\frac{1}{2} \times \frac{3}{8}$ inch.

Suspensions. By carefully adjusting the weight of the coil to the size of the phosphor-bronze suspension, we have practically eliminated the zero set, but for those who prefer the steel suspension this will be furnished.

Complete as illustrated **$32.00**

93–232 EXTRA COILS, either Ballistic, low, or high resistance as specified, are furnished for use with the above instrument . . . . . Each **7.50**

93–235 RADIO MICROMETER. In scientific work the Radio Micrometer has long been recognized as not only the most sensitive, but the most reliable heat indicator produced. In putting this sensitive instrument into practical form, we have used the fundamental parts of the D'Arsonval Galvanometer, — magnet system, mirror and reading device, but with the moving coil replaced by a most sensitive thermo-electric couple which it is possible to construct, with a suspension to hold the couple in position, and designed to introduce the least possible amount of restraining influence.



No. 93–235

Sensibility. In radio-micrometer work, the candle flame at definite distance has been found a convenient standard. It is possible with our instrument to detect the heat radiated from a candle flame at a distance of 50 feet, giving clearly indicated readings on the dial.

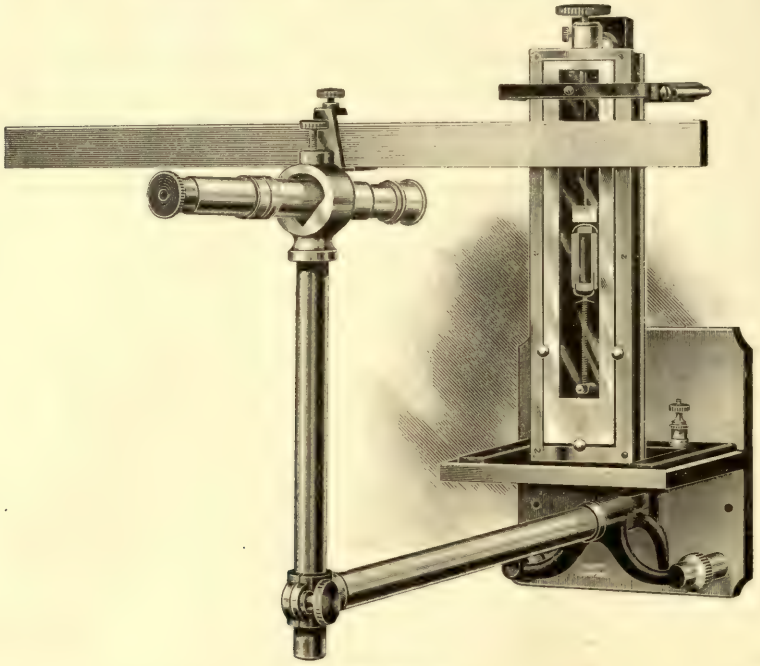
Method of Reading. With many radio-micrometers previously constructed, the readings must be taken with the telescope method owing to the fact that the deflections caused by the heat of the body make it necessary for the observer to remain at a considerable distance. Much of this difficulty has been overcome by our method of introducing heat to the thermo system. The directing horn is mounted on a movable ring so that the heat may be taken either from one side of the instrument or the other, but not from the front where the observer would naturally stand. The moving system being provided with a mirror and the close-reading scales easily removable, the telescope method of reading will be found in some cases more satisfactory.

Complete instructions for use will be furnished with each instrument.

Complete as illustrated **$15.00**

UNIVERSAL GALVANOMETER WALL-BRACKET AND TELESCOPE SCALE

ADAPTED TO ANY TYPE OF INSTRUMENT

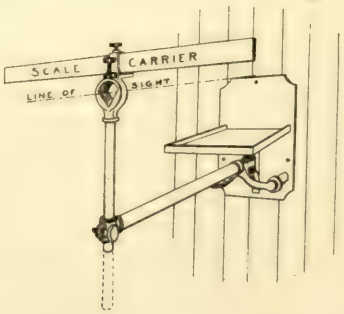


No. 93–245

93–240 GALVANOMETER WALL-BRACKET and **TELESCOPE SCALE.** Heretofore sensitive galvanometers have been attached rigidly to the wall, it being necessary to level them with the greatest care. When once attached and adjusted, the galvanometer is allowed to remain on the wall permanently.

Our rigid wall shelf for galvanometer work, carrying the telescope arm and scale, gives a method of using galvanometers much more satisfactory than has ever before been offered. It was especially designed for use with the self-centering instrument No. **93–230**, although any of our D'Arsonval instruments may be used on it. For lecture table demonstration this shelf will be found of especial service. For this work we recommend the use of the bracket only, the light being supplied from the Liliputian lamp, No. **70–125.**

Wall Bracket, Telescope and Scale **$16.50**

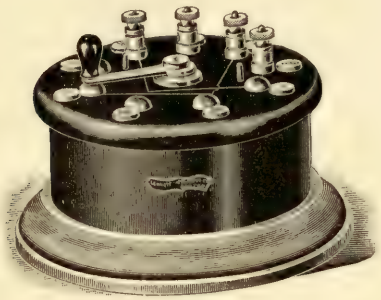


93–242 GALVANOMETER WALL-BRACKET only, without Telescope and Scale **$9.50**

93–245 GALVANOMETER WALL-BRACKET, TELESCOPE and **SCALE** together with No. **93–230 SELF-LEVELING D'ARSONVAL GALVANOMETER** complete as illustrated **48.50**

TELESCOPE. See No. **93–480.**

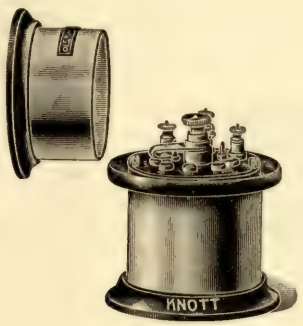
SHUNTS



No. 93–350

93–350 ELEMENTARY AYRTON UNIVERSAL SHUNT. In using a galvanometer of high sensibility it is necessary both for convenience and for protection of the galvanometer to use some device for reducing the strength of the current through the galvanometer. Separate shunts of the proper resistance may be used to bring the deflection down within the limit of the scale, but where it is desirable to send through the galvanometer at different times several different proportions of the main current the separate shunts become inconvenient. The instrument above illustrated provides in compact form a means of sending small or large fractions of the main current through the galvanometer, merely by a movement of the contact arm. This shunt is suitable for galvanometers with ranges from 50 to 500 ohms resistance.

Instrument is constructed with the greatest care, coils are accurately tested before shipment, and all parts are handsomely and durably finished **$7.50**



No. 93–360

93–360 UNIVERSAL SHUNT. A great advantage of this shunt over the one preceding is that it can be used with a ballistic galvanometer as well as with a dead-beat instrument. The instrument above illustrated has all the advantages of a universal form and in addition has the latest improved sliding contact which replaces the less convenient plug arrangement. The contact resistance is very low, although this is not a matter of great importance in the ordinary use of the instrument, as the contact resistance does not enter the galvanometer circuit proper. The circuit arrangements in our instrument are so arranged that the resistance coils are also available as a " drop wire," or simple potentiometer for subdividing a potential difference.

This instrument has received the most painstaking care in its construction as well as design. To protect the ebonite top from air, dust, and sunlight, thus preserving its insulating properties, a brass cover with mahogany top similar in style to the box is provided. It lifts clear away from the box on loosening a bayonet catch and is laid aside while the shunt is in use.

	a	b	c
Total Resistance .	10,000	20,000	100,000 ohms
Each	**$28.50**	**38.00**	**62.00**

93–370 UNIVERSAL SHUNT, similar to above, but without cover.

	a	b	c
Total Resistance .	10,000	20,000	100,000 ohms
Each	**$25.00**	**34.50**	**58.50**

GALVANOMETER ACCESSORIES

93–400 **PLANE GALVANOMETER MIRROR,** optically plane, diameter ½ inch **$0.75**

93–402 **ONE-METER CONCAVE GALVANOMETER MIRROR,** one-meter focus, diameter ½ inch . . . **1.00**

93–405 **TWO-METER CONCAVE GALVANOMETER MIRROR,** two-meters focus, diameter ½ inch . . **1.20**

93–415 **NICKEL SUSPENSION FILAMENTS.** Owing to freedom from oxidation, high fusing point, and the ability to draw it to a fineness suitable for suspensions, nickel as a suspension filament has come into considerable favor.

	a	b	c	d	e
Diameter	.001	.0015	.002	.003	.004 inch
Per Foot	**$0.27**	**.20**	**.15**	**.12**	**.10**

93–425 **PHOSPHOR-BRONZE FILAMENTS.** Phosphor-bronze has been used with success as suspensions in the highest grade electrical instruments. Owing to its great tensile strength and non-magnetic qualities, it is of special advantage where high sensibility is desired.

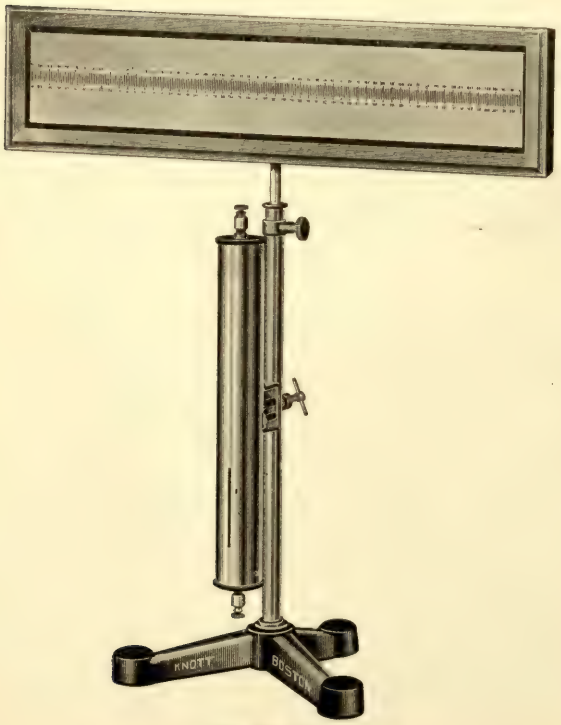
	a	b	c	d	e
Diameter	.001	.0015	.002	.003	.004 inch
Per Foot	**$0.27**	**.20**	**.15**	**.12**	**.10**

93–435 **STEEL SUSPENSION FILAMENTS.** Steel, as a suspension, is free from "set" and has great tensile strength.

	a	b	c	d	e
Diameter	.001	.0015	.002	.003	.004 inch
Per Foot	**$0.27**	**.20**	**.15**	**.12**	**.10**

93–445 **WOLLASTON WIRES,** the finest size of platinum wire filament; the wire before drawing, is enclosed in a silver sheath and is drawn through a jewel gauge (according to Wollaston) until the smallest size is obtained. The silver film that still remains must be removed chemically before the wires are used.

	a	b	c
Diameter of Platinum Core	.00006	.00008	.0001 inch
Approximate External Diameter	.006	.008	.0036 inch
Per Foot	**$1.25**	**.60**	**.60**

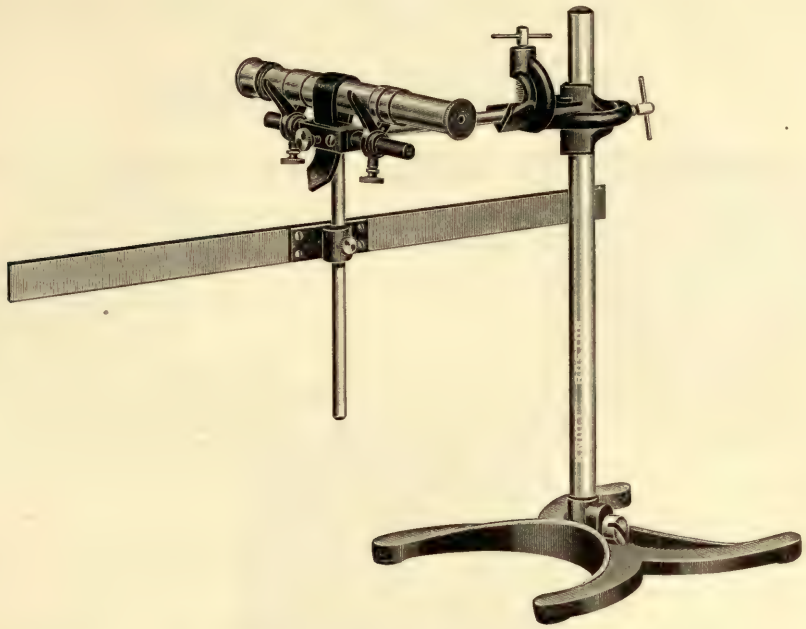


No. 93–460

93–460 **DIRECT READING ADJUSTABLY MOUNTED LAMP AND SCALE, "Lin-o-Lite" Lamp, Opalescent Screen,** for use with any reflecting galvanometer to give direct readings of the movement of the coil.

In the design above illustrated, we mount a single filament incandescent light within a cylindrical tube, the glowing filament showing through only a small opening in the cylinder. This cylinder is provided with a clamp for attachment to the supporting rod of the stand on which it is readily adjustable. The opalescent screen is mounted in a frame which is provided with a rod telescoping into the supporting rod of the stand. This screen has a scale across its entire length with long centimeter divisions and shorter millimeter divisions. This scale reads both ways from zero in the center. All parts of this apparatus are carefully made and the instrument has been of great utility in the many laboratories where it has been adopted.

Complete as illustrated **$11.25**



MOUNTED READING TELESCOPE AND SCALE

The only distinctive items illustrated above and not elsewhere listed are:

93–470 READING TELESCOPE SCALE. This scale is printed on glazed bristol board, 50 centimeters long, graduated in long centimeter divisions with shorter millimeter divisions either side from zero at the center, figures inverted. This scale is mounted on a hardwood strip provided with clamp for attachment to any 10-millimeter rod **$1.40**

93–480 READING TELESCOPE WITH CROSS HAIRS, objective 18 millimeters diameter, focus ½ to one meter, sliding tube focusing adjustment. This telescope is carefully constructed of the best obtainable material, the optical parts having been calculated to a nicety. The tubes are beautifully polished and lacquered and the objective is furnished with a brass cap. This telescope is especially designed for use in electrical measurements, but may be used equally as well in experiments on determining the magnifying power of a telescope **6.00**

Other apparatus illustrated above, and listed elsewhere is as follows:

43–271	**HARCOURT SPECIAL H-BASE,** for 19-millimeter rod	**$1.00**
5–20b	**SUPPORT ROD,** 19 millimeters diameter	**.52**
5–770	**HARCOURT RIGHT ANGLE CLAMP**	**.95**
5–920	**TELESCOPE CLAMP**	**2.45**
5–10b	**SUPPORT ROD,** 10 millimeters diameter	**.18**

70–110 ELECTRIC LAMP, table size, adjustable from 12 to 18 inches, made of polished brass, nickel-plated. Complete as illustrated in Section 70 . . . . . **8.75**

70–112 GAS LAMP, similar to above, but arranged for burning illuminating gas. Complete with Argand Burner and six feet of rubber tubing, with goose-neck connection, stand adjustable from 12 to 18 inches **6.90**

70–115 KEROSENE LAMP, similar to above, but arranged with reservoir for oil. Complete **8.75**

For **LILIPUTIAN PROJECTION LAMP,** highly recommended as a source of light for galvanometer work, see page **306.**

D'ARSONVAL TYPE AMMETERS AND VOLTMETERS DOUBLE RANGE

No. 93–525

This Double Range D'Arsonval line of instruments is offered as a distinctively higher grade line than those which have been commonly used by students in laboratory practice. The D'Arsonval movement, the aging of the magnets, the adjusting of the control spring and jeweled bearing, are features to which special attention has been given by our best instrument makers.

SCALE. Each instrument is made with two scales so as to cover as wide a range as will be needed in any kind of work. Each scale is individual, calibrated, and hand drawn, the higher range drawn in black, and the lower range in red with binding posts carefully differentiated to avoid burning out by careless connections. The zero of each scale is at the left, giving wide scale divisions.

93–525 D'ARSONVAL LABORATORY AMMETER, jewel bearings, aluminum case, hand calibrated. Range 0–25 amperes, scale drawn in black; 0–5 amperes, scale drawn in red **$9.40**

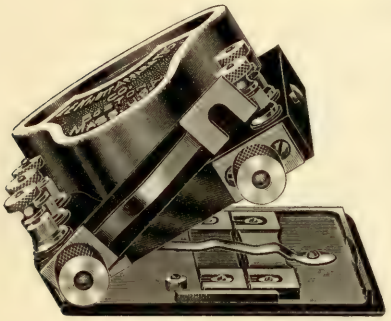
93–535 D'ARSONVAL LABORATORY VOLTMETER, jewel bearing, aluminum case, hand calibrated. Range 0–120 volts in 2-volt divisions in black, 0–12 volts in ⅕ volt divisions in red **9.40**

WESTON AMMETERS AND VOLTMETERS, LABORATORY TYPE

93–550 DOUBLE RANGE AMMETER, 0–25 amperes
0–5 amperes **$16.25**

93–560 DOUBLE RANGE VOLTMETER, 0–150 volts
0–15 volts **16.25**

THE REMOVABLE SHUNT TRIPLE RANGE VOLT-AMMETER



No. 93–600
Patent Pending

Our Universal **Voltmeter** and **Ammeter** has been designed to give, in practical working form, all the ranges required in such work as is usually taken in technical school and vocational school laboratories, one instrument serving the purpose of six of the usual form commercial type. By this means it is possible to supply a complete working equipment for an entire laboratory division covering the ranges required for all practical measurements at an expense well within the reach of the average school desiring to give instruction in practical electrical measurements.

This instrument is of a distinctly high grade and designed for practical work, every possible provision having been made against liability of injury. Should, in the course of rough handling, the pointer be moved slightly from zero, ample provision has been made for ready re-setting, insuring the same degree of accuracy as the instrument originally had.

The ranges covered are as follows: —

Voltmeter, 0–150 volts,
0–15 volts,
0–3 volts,
Ammeter, 0–30 amperes,
0–15 amperes,
0–3 amperes.

Voltmeter. The resistances giving the various ranges are permanently attached, each brought out to its appropriate binding post, and cannot, therefore, be disconnected.

Ammeter. The various ranges of ampere needs are met by the use of our new form interchangeable shunt, the same as used in our Universal Galvanometer No. **93–130.**

Additional shunts may be supplied, if desired, giving other ranges than those specified. Shunts which are not in use are carried on the inside of the base, as noted in the illustration.

Mounting. Both the cap and base are of aluminum. The base is made separable to provide carrying space for the shunts not in use.

Binding Posts. Each binding post is clearly marked, giving use and range for which it is designed, thus avoiding possibilities of error resulting from wrong connections.

Scales. Various scales are carefully differentiated so that no error may be introduced into the work by carelessness in reading. It will be seen that we have covered in a most satisfactory way the six most important ranges of laboratory instruments and provided against every possible contingency in practical use.

93–600 THE REMOVABLE SHUNT TRIPLE RANGE VOLT-AMMETER $20.00

WESTON TRIPLE RANGE AMMETERS AND VOLTMETERS, LABORATORY TYPE

93–625 TRIPLE RANGE VOLT-AMMETER, laboratory type, covering three ranges of Voltmeters, three ranges of Ammeters, as follows: —

Volts, 0–150
0–15
0–3
Amperes, 0–30
0–3
0–1½ **29.75**

VOLT-AMMETERS

MAGNETIC VANE TYPE

Volt-ammeters. The line of Volt-ammeters which we list herewith is of the well-known **magnetic vane type** with **zero center** which avoids injury in case of wrong connections. This is a type of instrument which will commend itself to Physics teachers because of the readiness with which the student may obtain results reading directly in the fundamental units of Volts and Amperes, thus learning at the very beginning of his work the significance of the common commercial terms.

Double scale, jewel bearing, aluminum case with hand calibration, combine to give this instrument a value in laboratory work not equaled by any other medium-priced instrument on the market.

Ranges. The ranges selected are such as will be of the widest service in laboratory work.

93–650 **VOLT-AMMETER,** magnetic vane type, jewel bearing, aluminum mounting, range 10 volts and 10 amperes **$6.50**

93–670 **VOLT-AMMETER,** magnetic vane type, range 120 volts and 15 amperes **8.50**

NEW LINE OF ALTERNATING CURRENT AMMETERS AND VOLTMETERS

It is doubtless due to the great advance which has been made during the past few years in the production of iron with definite electrical qualities, that the alternating current measuring instrument has now reached its present high state of perfection. It is with pleasure that we call the line we here offer to the attention of laboratory workers.

Voltmeter. A thoroughly reliable Voltmeter giving a full scale deflection on 15 volts, a voltmeter of higher resistance than is commonly used in commercial instruments.

Ammeter. Our alternating current Ammeters will measure with commercial accuracy the output of magnetos and even the smallest size alternating current generators. The Ammeters in this class are of much lower resistance than the conventional type of alternating current instruments.

Mounting. These instruments are mounted in a 7-inch finely finished iron case with nickel trimmings and in the usual switchboard form. See the illustration above.

93–700 **VOLTMETER,** 7-inch case, 0–15 volts **$14.00**

93–710 ——, 0–125 volts **14.25**

93–720 ——, 0–500 volts **19.00**

93–740 **AMMETER,** 7-inch case 0–1 ampere **13.00**

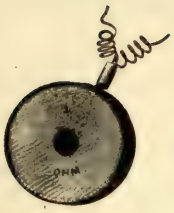
93–750 ——, 0–5 amperes **13.50**

93–760 ——, 0–25 amperes **13.50**

93–770 ——, 0–100 amperes **13.75**

ELECTRICAL RESISTANCE APPARATUS

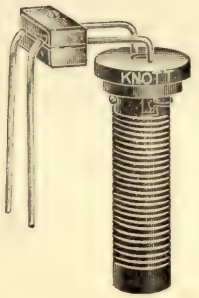
RESISTANCE COILS



No. 94–20

No. 94–21

No. 94–30



No. 94–60

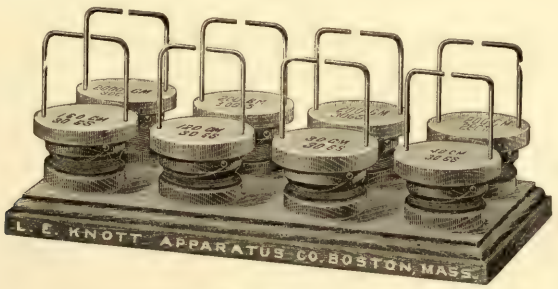
94–20 **ONE-OHM RESISTANCE,** after Millikan & Gale's "A Laboratory Course in Physics," Experiment 33 . . . . . **$0.28**

94–21 **THOUSAND-OHM RESISTANCE COIL,** after Millikan & Gale's "A Laboratory Course in Physics," Experiments 31 and 32 . . . . . **.45**

94–30 **SPOOL RESISTANCES.** These spools are practically the same as those which are used in our high-grade resistance boxes. They are guaranteed to be accurate to ⅛ of one per cent.

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	
Resistance	1	2	3	4	10	20	30	40	50	100	200	300	400	1000	2000	3000	4000	Ohms
Each . .	**$0.50**	**.55**	**.55.**	**55**	**.60**	**.62**	**.65**	**.68**	**.75**	**.80**	**.85**	**.95**	**1.00**	**1.50**	**1.75**	**2.00**	**2.20**	

94–60 **TEMPERATURE COIL,** for use with Wheatstone Bridge in the study of effect of temperature changes on the resistance of a coil of wire.
This instrument consists of a spool of insulating material on which is mounted a coil of high resistance, the ends of which are terminated in heavy leads.
Complete as illustrated **$1.20**

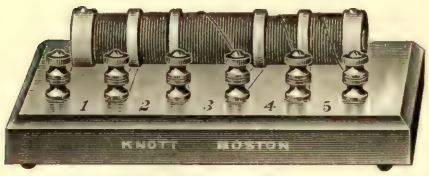


No. 94–70

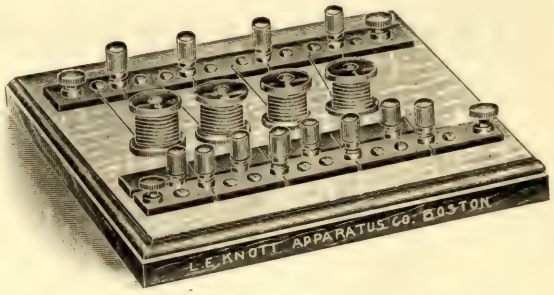
94–70 **RESISTANCE COILS, HYDE FORM,** for use with Wheatstone Bridges, in determining the resistances of coils; also for formulating laws of resistance in wires. In our new design we have entirely obviated the danger of the ends of the coil becoming detached from the leads, — a very great advantage over the old forms.
As illustrated, this instrument consists of eight spools, of different lengths and different diameters and two different materials. Each spool is mounted on a pin fixed in a neatly finished baseboard.
To simplify the deriving of the laws of resistance we furnish eight spools capable of securing the following combinations: —

2 Spools, same material, same diameter, same length.
2 Spools, same material, same length, different diameters.
2 Spools, same material, same diameter, but one double the length of the other.
2 other Spools which, with combination with those above cited, will allow of comparison, of same diameter and same material, but of lengths as 1: 2: 3: 4: 5.
1 other Spool of same diameter but different material from one of the above named, but exactly ten times the length.

Set of eight spools complete, mounted on base as illustrated **$3.00**



No. 94–80



No. 94–90

94–80 RESISTANCE SPOOLS. Set of five spools of unknown resistance, all mounted on same spindle on a polished wood base, each with binding posts for connections to each or to all in the series.

This combination consists of the following spools:

10 meters No. 22 Copper Wire
10 meters No. 28 Copper Wire
20 meters No. 22 Copper Wire
20 meters No. 28 Copper Wire
10 meters No. 22 German Silver Wire

Per Set **$3.30**

94–90 RESISTANCE BOARD, after C. H. Andrews of the South High School, Worcester, Mass.

This instrument consists of four bobbins, the wire so wound and connected as to make possible combinations as follows:

2 Coils of the same length and material, but of different diameters.
2 Coils of the same length and diameter, but of different material.
2 Coils of the same diameter and material, but of different lengths.

In the design of this instrument Mr. Andrews has taken pains to select wires whose diameters and resistances have convenient ratios to each other and, therefore, best suited for use in parallel. The coils have the further advantage that they are so connected to the brass blocks that combinations in series or parallel of any one or more of the coils may be secured by proper placing of the plugs in their tapered holes.

This instrument is very carefully constructed; the plugs are nicely tapered and ground to fit the holes.

Mounted as illustrated on a finished hardwood base **$4.50**

Nos. 94–100 to 94–105

94–100 STANDARD RESISTANCES. The coil illustrated has been designed for use whenever the highest accuracy is not required, and the inconvenience attending the use of an oil bath can therefore be avoided. Though not intended as the highest standards, the accuracy and compactness make these coils convenient for many purposes. The winding is a matter of great care; the wire used is manganin, and the core on which the coil is wound is of brass. This core is open at each end, giving ventilation as well as preventing changing of temperature; also permitting the introduction of a thermometer into the interior. The winding is arranged in a thin layer on the core and insulated with only sufficient wax to prevent access of the air to the wire.

The case is of brass; the terminals are heavy copper rods giving ample conductivity and contact surface. The lower ends of these rods are arranged to dip into mercury cups, while the upper ends are equipped with large binding posts screwing into the copper bars and bearing against lugs which give ample clamping surface.

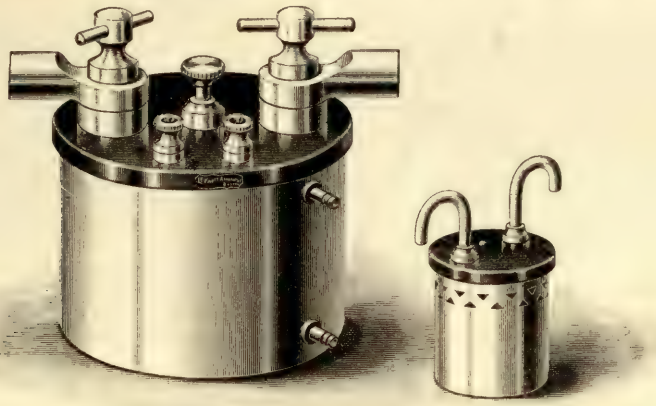
These coils are furnished in four different sizes as listed below. They are accurately adjusted to $\frac{1}{100}$ of one per cent. With each coil a certificate of accuracy giving the date, temperature, and precise value of the resistance at the final test is included.

	a	b	c	d
Capacity	1	10	100	1000 ohms
Each	**$10.00**	**10.50**	**12.50**	**15.50**

94–105 STANDARD RESISTANCES, same as above, but adjusted to an accuracy of $\frac{1}{10}$ of one per cent. With these coils the certificate is not furnished.

	a	b	c	d
Capacity	1	10	100	1000 ohms
Each	**$7.50**	**8.00**	**9.50**	**12.50**

STANDARD RESISTANCES



Nos. 94–115 to 94–117

94–115 STANDARD RESISTANCES, Reichsanstalt Form, universally accepted for work of high precision. These have been evolved as an embodiment of the long experience of the German Government Bureau. The resistance material of these standards is manganin, selected not only for its approved permanence and low temperature resistance coefficient but also for its small thermo-electro-motive force against copper. The external case is not in connection with the winding and furnishes merely a mechanical support and protection. The standard may be immersed in oil so that the coil is completely submerged, and the case, bobbin, and winding are so arranged that the oil has access to all parts of the coil, making it possible to ascertain or control its temperature with certainty. An opening through the ebonite top permits the insertion of a thermometer into the interior. Case and terminals are nickel-plated to prevent corrosion. Every operation of the construction of these standards, winding, aging, and adjustment, is most carefully carried out. Our standards will therefore be found not merely accurate in adjustment but also permanent in calibration. Each coil is adjusted to $\frac{1}{100}$ of one per cent of the value of our copies of the United States Standard. With each resistance sent out is a certificate of accuracy for each coil.

	a	b	c	d	e
Capacity	$\frac{1}{10}$	1	10	100	1000 ohms
Each	**$45.00**	**45.00**	**45.00**	**45.00**	**45.00**

94–117 STANDARD RESISTANCES, Reichsanstalt Form, same accuracy and general structure as above, but arranged for air cooling only.

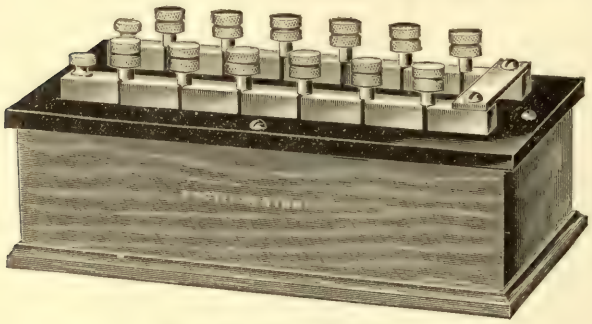
	a	b	c	d
Capacity	1	10	100	1000 ohms
Each	**$20.00**	**20.00**	**20.00**	**22.50**

94–125 SINGLE-COIL TENTH MEGOHM. In the construction of this box we use one of the units of our Standard Megohm Box No. **94–225,** mounted in a cylindrical brass case with raised terminals, thermometer hole, and offered in form as illustrated.

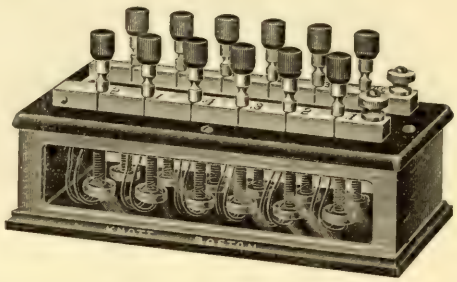
Tenth Megohm Coil as illustrated **$35.00**

No. 94–125

RESISTANCE BOXES



Nos. 94–152 to 94–155



No. 94–160

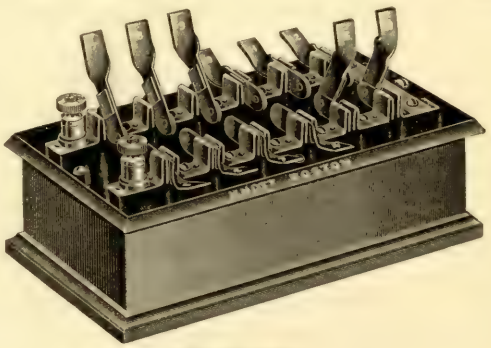
94–150 **SCHOOL RESISTANCE BOX,** range 1 to 20 ohms, guaranteed accuracy of ½ of one per cent. . . . **$3.75**

94–152 **SCHOOL RESISTANCE BOX,** range $\frac{1}{10}$ to 111 ohms, guaranteed accuracy of ⅕ of one per cent . . **7.50**

94–155 ——, same as above, but with certificate from our electrical laboratory **10.00**

94–160 **SCHOOL DEMONSTRATION RESISTANCE BOX.** This box is the same as above but supplied with glass front and back that students may see the internal construction of a resistance box. By this method the coil connections may readily be observed, and the pupil is enabled to judge for himself the structure of an ordinary resistance box **9.50**

94–170 **B-P SWITCH RESISTANCE BOX.** The illustration above shows our resistance box fitted with the new **B-P Switch** in which we believe a great step has been taken in the proper direction, for this simple device comprises the good points of the plug and associates with them the valued features of a switch mechanism. In the design of the switch care has been taken to retain only the good features and it will be found both rapid and dependable in accurate work.

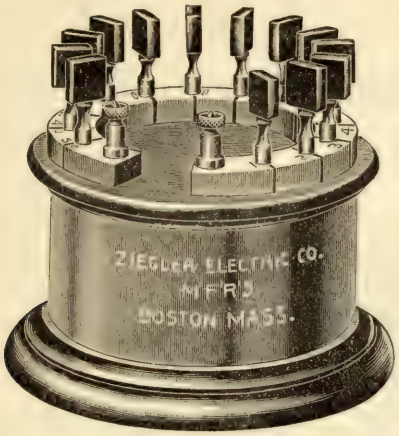


No. 94–170
Patent Pending

POINTS OF MERIT

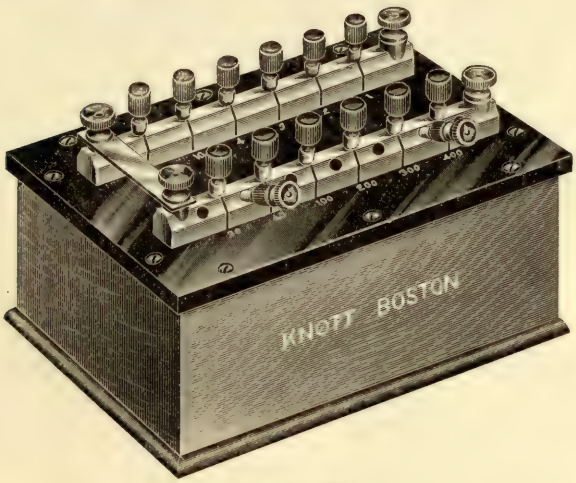
1. One throw of the hand puts a coil in or out of circuit as desired.
2. The closing of the switch is always accompanied with a wedging rubbing action similar to that met with in perfectly fitted plugs.
3. The resistance of the closed switches is extremely low.
4. It is not necessary to open the switches when not in use, as the expansion of the rubber upon which they are mounted can do no harm.
5. There are no loose parts to become lost or mixed.
6. The values of the coils in or out of circuit can be told at a glance.
7. The values of the coils are marked upon the switch blade handles, which are always up in plain sight when open, so that it is not necessary to get directly over the box to obtain their values.
8. Portions of the switch device extend through the top of the resistance box and are directly soldered to the coil terminals, thereby insuring against unreliable screw contact joints, etc.
9. The simplicity of construction enables drawn metal of unusually low and uniform resistance to be used to advantage.
10. There is no chance for dirt and filings to lodge and short-circuit the coils.
11. It is very rapid.
12. Perfection of contact does not depend upon accurately reamed contact surfaces that may be badly injured by use or abuse.

The coils contained in this box are made and tested by our standard process, and their accuracy is fully equal to that of any box on the market. The coils are each guaranteed accurate to ½ of one per cent. The total resistance is 111 ohms divided as follows: — 0.1, 0.2, 0.3, 0.4, 1, 2, 3, 4, 10, 20, 30, 40 ohms **$6.60**



No. 94–180

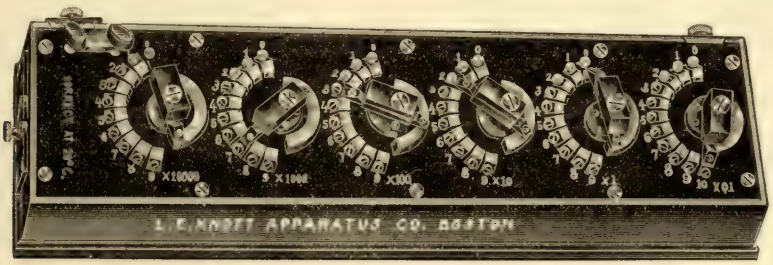
94–180 SUPERIOR ROUND FORM PLUG RESISTANCE BOX. This box is an excellently finished, reasonably priced high-grade instrument. Contains 13 coils ranging from 1/10 to 50 ohms, with total resistance of 161 ohms. Each instrument is guaranteed accurate to within 1/5 to 1/10 of one per cent **$10.00**



No. 94–190

94–190 TRAVELING PLUG RESISTANCE BOX. This box is provided with extra heavy brass blocks and reinforced ebonite top. Contains 12 coils ranging from 1 to 400 ohms, with total resistance of 1110 ohms. The usefulness of the instrument is increased by the addition of two traveling plugs facilitating its use in the comparison of electro-motive force of batteries, and other tests. Guaranteed accuracy of 1/5 to 1/10 of one per cent **$25.00**

94–195 TRAVELING PLUG RESISTANCE BOX, similar to above but constructed for greater range. Contains 16 coils ranging from 1 to 4000 ohms with total resistance of 11,110 ohms. Guaranteed accuracy of 1/5 to 1/10 of one per cent **30.00**

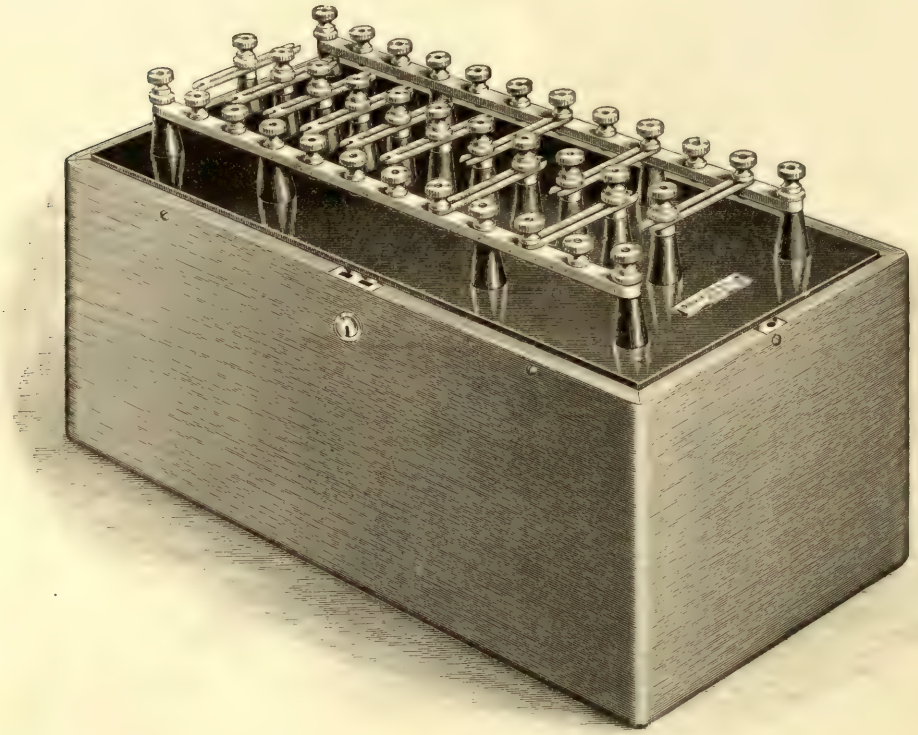


No. 94–200 d

94–200 DECADE RESISTANCE BOX, with sliding contact and connections; best material, highest accuracy, improved positive contact secured by the laminated contact brushes.

	a	b	c	d
No. of Decades	3	4	5	6
Duty Free	**$90.00**	**118.00**	**140.00**	**165.00**

MEGOHM BOX



No. 94–225

94–225 **STANDARD MEGOHM BOX, range 10,000 to 1,000,000 ohms,** an arrangement for a megohm resistance which gives the greatest attainable flexibility and convenience without diminishing the accuracy.

General Arrangement. Highly insulated binding leads, easily accessible buss bars for changing of the connections. A total resistance of one megohm is obtained by putting 10 coils, each of 100,000 ohms, in series. Joining in multiple, a minimum resistance of 10,000 ohms is obtained. Any range between the two in steps of 10,000 ohms is readily obtained. The importance of this arrangement in accurate comparisons of high resistances cannot be overestimated.

Insulation. Perfect insulation is a requisite in all high resistance work. As will be noted, the box is made of large proportions, raised ebonite insulated terminals, so designed as to be easily cleaned. This feature should not be overlooked in practical work. The box is also provided with a cover, not shown in the illustration. This feature we consider essential in order that the insulating qualities of the ebonite may be retained.

Connections. Note the new sliding link running from buss bars to binding posts. This adds greatly to the convenience of connecting, insures against any of the connectors being lost and makes it possible to attain quickly the necessary changes in the least possible room.

Coils. The coils are wound non-inductively with our special "B" high resistance wire, which we consider for purposes of a megohm box superior to manganin as used in all of our low range boxes. Each coil is thoroughly protected from moisture by wax and insulating covering, which also seems to give to each unit ability to withstand mechanical strains.

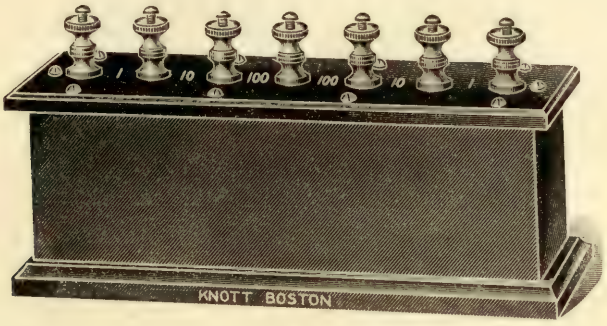
Standard Megohm Box **$140.00**

94–230 **STANDARD TENTH MEGOHM BOX.** We have had frequent calls for a box similar to our No. **94–225**, but utilizing the Wolff method of connecting and other features in its construction, but of lower range. We therefore offer the same box with the same number of coils but of lower unit denomination, making the total resistance of the box $\frac{1}{10}$ megohm. Each coil has a resistance of 10,000 ohms; 100,000 ohms may be secured by connection in series, 1,000 ohms by connection if in multiple.

Standard Tenth Megohm Box **100.00**

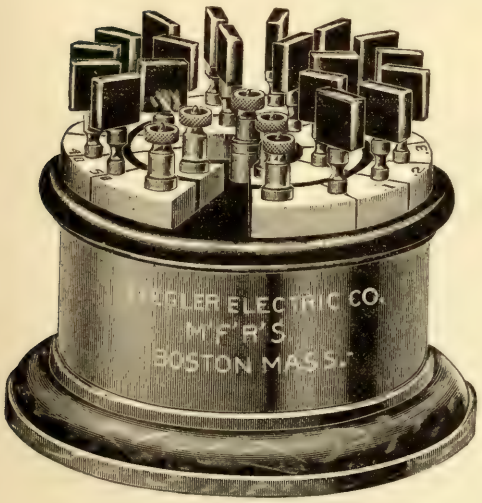
Standard Tenth Megohm Coil. See No. **94–125.**

COMBINED BRIDGE AND RESISTANCE BOXES



No. 94–250

94–250 RATIO BOX. In Wheatstone Bridge work it is essential that easily accessible ratio arms be provided. This box has been designed for this particular purpose. It contains six coils as follows: — 1, 10, 100, 100, 10, and 1 ohms, which will give nine different working ratios. Each coil is guaranteed accurate to $\frac{1}{10}$ of one per cent. It may therefore be seen that with this accuracy the ratio box may be used as a standard resistance of 222 ohms capacity **$10.60**



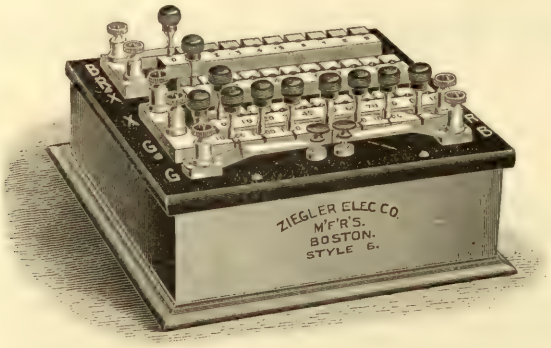
No. 94–260

No. 94–270

94–260 ROUND TYPE PLUG BRIDGE AND RESISTANCE BOX. Contains 13 coils ranging from $\frac{1}{10}$ ohm to 50 ohms, giving a total resistance of 161 ohms, in addition to the bridge coils which have the following resistance of: 100, 10, 1, 1, 10, and 100 ohms. It may therefore be seen that the total range is from .001 ohm to 17,600 ohms. This instrument is recommended as one of great accuracy, giving a wide range. Guaranteed accuracy of $\frac{1}{5}$ to $\frac{1}{10}$ of one per cent **$18.50**

94–270 IMPROVED COMBINED BRIDGE AND RESISTANCE BOX. Bridge coils are 1, 10, 100, 100, 10, and 1 ohms. Resistances range from 1 to 400 ohms. Total resistance 1110 ohms. Total range of measurements from .01 ohm to 111,000 ohms. Guaranteed accuracy $\frac{1}{5}$ to $\frac{1}{10}$ of one per cent . . . **25.00**

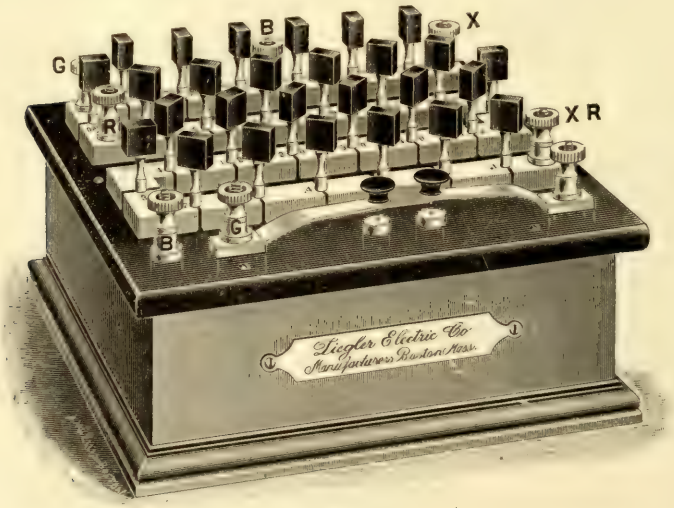
94–272 RESISTANCE BOX, same as above, but without bridge coils **20.00**



No. 94–280

94–280 ZIEGLER BRIDGE AND RESISTANCE BOX. This box has been especially designed to meet the constant demands for a reliable and conveniently arranged combined box giving a wide range yet one which can be furnished at a price within the appropriation of most schools.

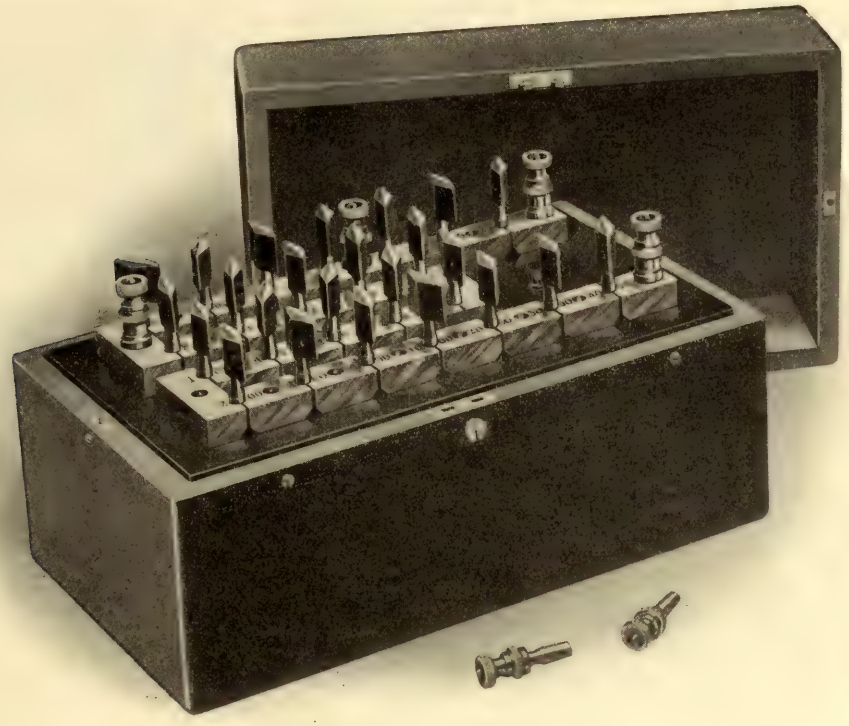
The first row of the resistance box contains nine ⅒-ohm coils; the second 10 1-ohm coils; the third ten 10-ohm coils. The total range of measurement, therefore, is from .001 ohm to 11,090 ohms. Separate keys properly connected for battery and galvanometer are mounted as illustrated. Coil accuracy guaranteed to ⅒ of one per cent **$34.75**



No. 94–285

94–285 ZIEGLER IMPROVED COMBINED BRIDGE AND RESISTANCE BOX. This box is in general similar to No. **94-280.** It has, however, a larger capacity and the blocks are extra heavy. The bridge coils are 1000, 100, 10, 1, 100, 1000 ohms. The resistance box coils range from ⅒ ohm up to 4,000 ohms. Total resistance 11,111 ohms. Range .0001 ohm to 11,110,000 ohms. Coil accuracy guaranteed to ⅒ of one per cent **$50.00**

PRECISION RESISTANCE BOX AND BRIDGE



No. 94–300

94–300 STANDARD PRECISION RESISTANCE BOX, designed to give the highest degree of precision of which the plug contact form of Wheatstone Bridge is capable; constructed to furnish the best that modern research has produced.

Range. The one-ohm Ratio Coil can be thrown into either arm desired by means of one of the traveling plugs supplied with the box. The range of the bridge is, therefore, from .001 to 11,110,000 ohms.

Resistance Arms —			
1	10	100	1000 ohms
2	20	200	2000 "
3	30	300	3000 "
4	40	400	4000 "
Bridge Arms —			
1	10	100	1000 ohms
	10	100	1000 "
Total			13,331 ohms

Accuracy. All the features tending to give permanency of calibration as well as accuracy have been studied in every detail. The coils in the ratio arms are adjusted to $\frac{1}{10}$ of one per cent; those in the ratio arms to $\frac{1}{20}$ of one per cent. With a proper handling of this box, results may be secured limited only by the inherent capabilities of the plug contact form.

For details of construction, see special circular which will be mailed upon request.

SPECIAL FEATURES

Coils of manganin wire, aged by our special process, wound on hollow brass bobbins, securing perfect insulation and greater carrying capacity, individually tested and attached by special arms permitting new coils to be furnished and attached by user.

The **Insulation** is of the very highest quality, interior of box practically moisture proof to insure permanency of insulation.

Connecting Blocks of unusually large size, of ample clearance and special provision for cleaning.

Traveling Plugs, — two furnished with each box.

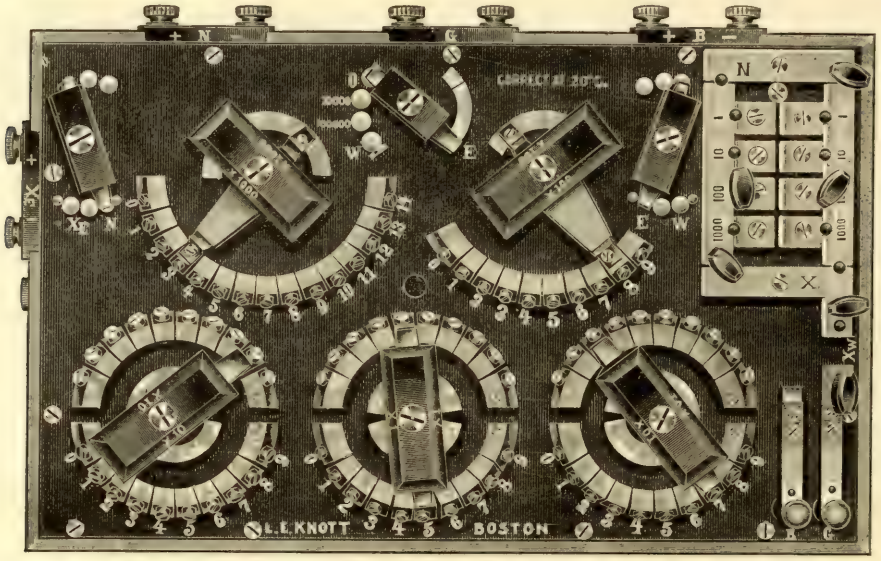
Coil Plugs, rubber handles, diamond form; tapers designed for constant use without contact error.

Grid Support, on interior of box to prevent springing of top by excess plug pressure.

Cover. Dust-tight, provided with each box to insure life of rubber top.

Standard Precision Resistance Box, as above described **$110.00**

POTENTIOMETER



No. 94–315

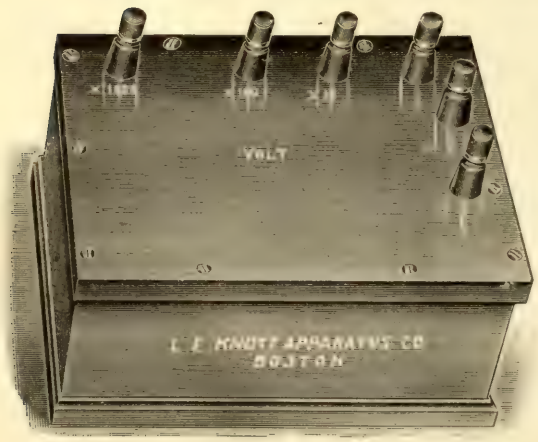
94–315 IMPROVED POTENTIOMETER, for rapidly and accurately measuring electromotive forces and currents, the latter by measuring the Fall of Potential on the ends of standard resistances. The form above illustrated is now used quite extensively where accurate electrical measurements are made, as the most reliable apparatus for measuring potentials.

The aggregate resistance of this apparatus is 15,000 ohms. This high resistance has the advantage over other designs in that the necessary connection and contact resistance are added to far higher resistances and, therefore, are practically negligible, and, further, that much smaller fractions of the potentials can be measured, without the danger of having too small resistances. The limit is 15 volts. If the fall of potential is one volt on 1000 ohms, the potential can be measured to .0001 volts, as .001 ohm is the smallest resistance and to 1.5 volts if the Fall of Potential is one volt on 10,000 ohms. Then 0.0001 volt can be measured directly if a sufficiently sensitive galvanometer is used.

This instrument contains, in addition, a double pole switch for the battery and four pairs of ratio resistances which may be interchanged by means of two plugs so as to eliminate the differences in the arms of the bridge. As comparison resistances the five decades are used. Auxiliary batteries with rheostat and galvanometer are used for both purposes. It is only necessary to turn the double pole switch noted in the right hand top and the single pole galvanometer switch to W and E respectively, and on the right, resistances, on the left, potentials can be measured. The standard cell and an electromotive force connected to the X terminal need not be removed when measuring resistances, as they are not within the circuit.

This instrument is made by one of the most prominent electrical instrument manufacturers in Europe. It is of the finest workmanship throughout, and receives the highest guarantee of quality from its manufacturer.

Potentiometer and Wheatstone Bridge, complete with 85 coils . . Duty Free, **$222.50**

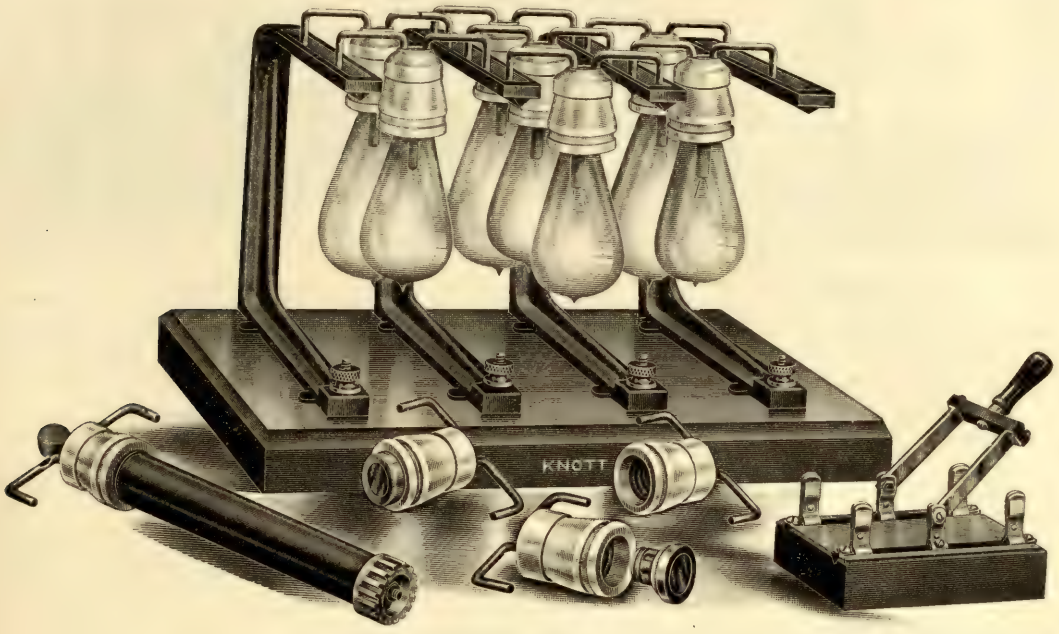


No. 94–320

94–320 MULTIPLIER, with 3 ranges. This apparatus is for use with Potentiometers, etc., and can be used in potentials up to 1,500 volts. The total resistance amounts to 100,000 ohms, and is composed of a large number of single coils for the sake of better insulation and cooling. The resistances are arranged in a box made of perforated sheet metal with wooden bottom. It can be placed at any distance from the Potentiometer, as the resistance in the connecting wire is of no importance.

Duty Free, **$55.00**

UNIVERSAL RESISTANCE FRAME



Patents Pending

A Group Cut illustrating the Following Numbers

The **Universal Resistance Frame** is a practical device for the regulation of lighting circuits for experimental and lecture purposes, possessing simplicity of construction, utility, convenience, adaptability, and educational features unapproached by any other rheostat, regardless of cost. This device comprises a heavy slate base upon which is mounted a series of substantial metal brackets fitted with binding screws for convenience in connecting into a lighting circuit. From these brackets are suspended as required lamp sockets and lamps or resistance units to any value desired, either in series or multiple or series-multiple, thus making it possible to realize unusual combinations, without closing switches or making complicated connections. A feature that will appeal to the user is that only the lamps or units in use are suspended at a time; thus the student is not confused by a number of lamps not in circuit as on the ordinary lamp rheostat board.

Lamp Sockets with lamps or resistance units are employed in our Resistance Frame. By proper connections of these resistances, ampere strengths varying from .2 to over 40 amperes may readily be obtained. An advantage, also, of this frame is that it may be used on any voltage with 110 volt lamps, an advantage not obtained by the ordinary lamp resistance board. The instrument is absolutely fireproof, conforming to the rules of the National Board of Fire Underwriters.

94–350 UNIVERSAL RESISTANCE FRAME, complete with Lamp Sockets and Lamps furnishing ampere strengths from .2 up to 6 amperes

Complete with six lamps **$11.00**

In many experiments the light from lamps in circuit is quite objectionable, and to secure a large amount of current, the outfit must of necessity be cumbersome. It is therefore advisable, and we list the following outfits equipped with resistance units, each of 200 watts capacity, giving 1.8 amperes.

94–352 UNIVERSAL RESISTANCE FRAME, complete with Resistance Units giving ampere strengths from .6 up to 7.2 amperes by .6 ampere steps **15.50**

94–355 UNIVERSAL RESISTANCE FRAME, complete with Resistance Units giving ampere strengths from .6 up to 18 amperes by .6 ampere steps **25.00**

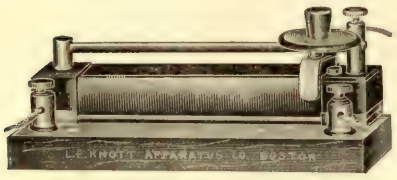
94–357 UNIVERSAL RESISTANCE FRAME, complete with Resistance Units, giving ampere strengths from .6 up to 40 amperes by .6 ampere steps **48.50**

94–360 MOUNTED DOUBLE POLE DOUBLE THROW KNIFE SWITCH, capacity 50 amperes at 250 volts, slate base, mounted on heavy slate sub-base **2.75**

RHEOSTATS

This type of Rheostat comprises a layer of high resistance wire wound on an insulating fire-proof slab mounted on a polished wooden base with asbestos shield. They are fitted with suitable slider and binding posts for connecting in the circuit. Their open construction commends them for general laboratory work.

In selecting a rheostat make sure that the ampere capacity is ample to meet the requirements.



No. 94–405

No. 94–410

BATTERY RHEOSTATS. The following capacities of the simple type instrument illustrated under No. **94–405** will be found well suited to battery or other low voltage circuits, or for use in connection with apparatus that consumes a large proportion of the energy of the power circuit.

Number	Voltage	Maximum carrying Capacity Amperes	Resistance Ohms	Size Inches	Weight Ounces	Price, Duty Free
94–400 A	12	7	1.7	$4\frac{3}{4} \times 1\frac{3}{16} \times \frac{19}{32}$	10	**$3.15**
94–400 B	15	10	1.5	$6\frac{5}{16} \times 1\frac{9}{16} \times \frac{19}{32}$	14	**3.85**
94–400 C	24	3	8	$4\frac{3}{4} \times 1\frac{3}{16} \times \frac{19}{32}$	10	**3.20**
94–400 D	25	10	2.5	$8 \times 2 \times \frac{3}{4}$	42	**6.00**

SIMPLE RHEOSTATS, especially adapted to power circuits.

Number	Voltage	Maximum carrying Capacity Amperes	Resistance Ohms	Size Inches	Weight Ounces	Price, Duty Free
94–405 A	800	.3	2400	$18 \times 2\frac{3}{8} \times 1\frac{3}{8}$	137	**$9.40**
94–405 B	112	.3	250	$4\frac{3}{8} \times 1\frac{3}{16} \times \frac{19}{32}$	10	**3.45**
94–405 C	110	1	110	$6\frac{5}{16} \times 1\frac{9}{16} \times \frac{19}{32}$	14	**3.95**
94–405 D	110	5	22	$16 \times 2 \times 1$	118	**8.25**

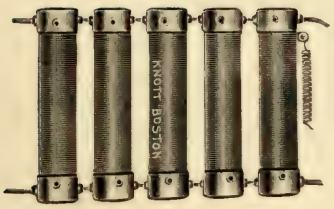
DOUBLE RHEOSTATS, similar to the previous type of instrument but comprising two wire-carrying mounted slabs on a common base. This construction enables a much larger capacity to be attained in a given space.

Number	Voltage	Maximum carrying Capacity Amperes	Resistance Ohms	Size Inches	Weight Ounces	Price, Duty Free
94–410 A	100	10	10	$12 \times 2\frac{3}{8} \times 1\frac{3}{8}$	150	**$11.25**
94–410 B	110	20	5.5	$18 \times 2\frac{3}{8} \times 1\frac{3}{8}$	218	**12.50**
94–410 C	140	7	20	$12 \times 2\frac{3}{8} \times 1\frac{3}{8}$	150	**10.25**
94–410 D	330	3	110	$12 \times 2\frac{3}{8} \times 1\frac{3}{8}$	150	**9.60**
94–410 E	700	1	700	$12 \times 2\frac{3}{8} \times 1\frac{3}{8}$	150	**9.60**

No. 94–415

94–415 SIX-INCH REGULATING RHEOSTAT. Designed primarily as a fan motor speed regulator, this rheostat has been modified for use as an adjustable resistance. Maximum watt capacity 125. Seven contacts, one "off" point and six running positions of 150 ohms per step. Maximum amperes 10.
Mounted on marbleized slate panel as illustrated **$3.50**

RESISTANCE UNITS



Resistance Units Grouped

No. 94–420

No. 94–425

No. 94–430

No. 94–435

RESISTANCE UNITS, approximate dimensions ¾ × 4 inches.

50 Watts Continuous Duty

Number	Maximum Amperes	Resistance Ohms	Duty Free, Price	Number	Maximum Amperes	Resistance Ohms	Duty Free, Price
94–420 a	0.45	250	**$0.95**	**94–420 h**	3.3	4.5	**$0.95**
—— b	0.6	125	**.95**	—— i	3.6	3.9	**.95**
—— c	0.8	75	**.95**	—— j	5	2	**.95**
—— d	1	45	**.95**	—— k	6.4	1.2	**.95**
—— e	1.25	32	**.95**	—— l	9	0.6	**.95**
—— f	1.7	16	**.95**	—— m	12	0.35	**.95**
—— g	2.3	9	**.95**	—— n	14	0.25	**.95**

RESISTANCE UNITS, approximate dimensions 1⅛ × 4¾ inches.

85 Watts Continuous Duty

Number	Maximum Amperes	Resistance Ohms	Duty Free, Price	Number	Maximum Amperes	Resistance Ohms	Duty Free, Price
94–425 a	0.45	420	**$1.25**	**94–425 h**	2.8	11	**$1.25**
—— b	0.6	220	**1.25**	—— i	3.2	8	**1.25**
—— c	0.8	140	**1.25**	—— j	5	3.5	**1.25**
—— d	1.0	85	**1.25**	—— k	6.2	2.2	**1.25**
—— e	1.2	60	**1.25**	—— l	8.5	1.1	**1.25**
—— f	1.6	32	**1.25**	—— m	11.5	0.65	**1.25**
—— g	2.2	18	**1.25**	—— n	14.4	0.4	**1.25**

RESISTANCE UNITS, approximate dimensions 1⅝ × 6¼ inches.

150 Watts Continuous Duty

Number	Maximum Amperes	Resistance Ohms	Duty Free, Price	Number	Maximum Amperes	Resistance Ohms	Duty Free, Price
94–430 a	0.45	800	**$1.45**	**94–430 h**	2.8	20	**$1.45**
—— b	0.6	450	**1.45**	—— i	3.2	13	**1.45**
—— c	0.8	240	**1.45**	—— j	5	6	**1.45**
—— d	1	150	**1.45**	—— k	6.5	3.5	**1.45**
—— e	1.2	95	**1.45**	—— l	8.5	2	**1.45**
—— f	1.6	54	**1.45**	—— m	12	1	**1.45**
—— g	2.2	32	**1.45**	—— n	14	0.8	**1.45**

RESISTANCE UNITS, approximate dimensions 1½ × 7 13/16 inches.

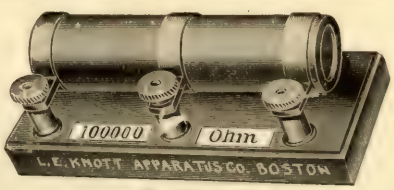
200 Watts Continuous Duty

Number	Maximum Amperes	Resistance Ohms	Duty Free, Price	Number	Maximum Amperes	Resistance Ohms	Duty Free, Price
94–435 a	0.45	1100	**$1.95**	**94–435 h**	2.8	27	**$1.95**
—— b	0.6	560	**1.95**	—— i	3.2	18	**1.95**
—— c	0.8	320	**1.95**	—— j	4.7	9	**1.95**
—— d	1	200	**1.95**	—— k	6.3	5	**1.95**
—— e	1.2	140	**1.95**	—— l	8.5	2.8	**1.95**
—— f	1.6	72	**1.95**	—— m	11.5	1.5	**1.95**
—— g	2.1	45	**1.95**	—— n	13	1.2	**1.95**

Nos. 94–420 to 94–435 not furnished from stock. Imported Free of Duty only when ten or more are ordered.

94–440 GRAPHITE HIGH RESISTANCE. This resistance will be found of great convenience in experimental and testing work. Its low price and excellent appearance recommend it for many purposes. Resistance is mounted on polished wood base provided with binding posts for connections. Capacity 1,000,000 ohms; size of cylinder 4⅜ × 1¾ inches . . . . . Duty Free **$9.75**

94–442 ——, same as above, but 100,000 ohms . . Duty Free **7.25**

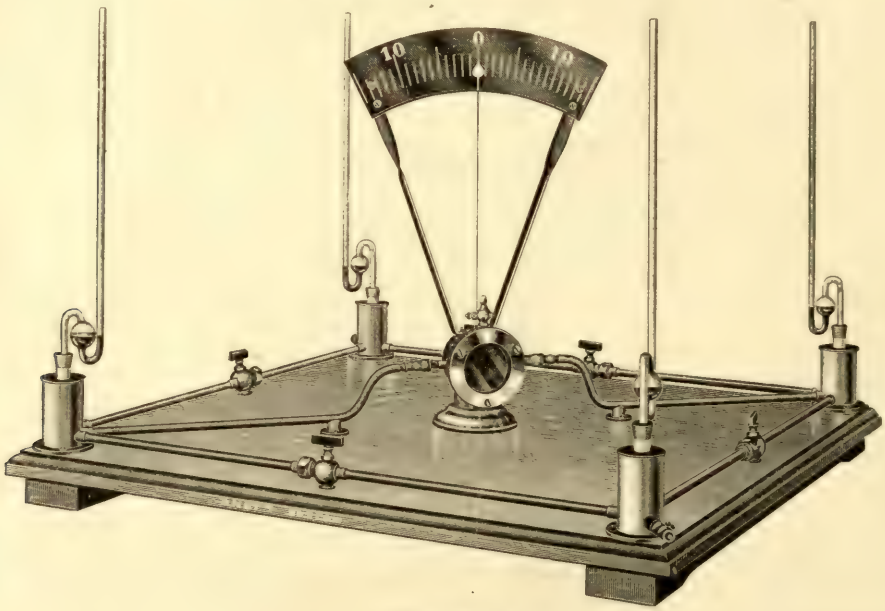


No. 94–442

WHEATSTONE BRIDGES

DEMONSTRATION WHEATSTONE BRIDGES

Too little attention has been given in schools to a thorough understanding of that basic principle, Fall of Potential, fundamental to Wheatstone Bridge work. A student's incomplete understanding of Fall of Potential makes it difficult for him to understand what he is striving to obtain when he uses a Wheatstone's Bridge. This incomplete understanding is due, perhaps, to the word of mouth descriptions and the lack of adequate illustrative demonstrative apparatus. To picture for him the actual Fall of Potential, we heartily recommend the following apparatus. The analogy between hydraulic pressure and electromotive force is often resorted to by teachers, yet the analogy has never been worked out instrumentally except in the following apparatus.



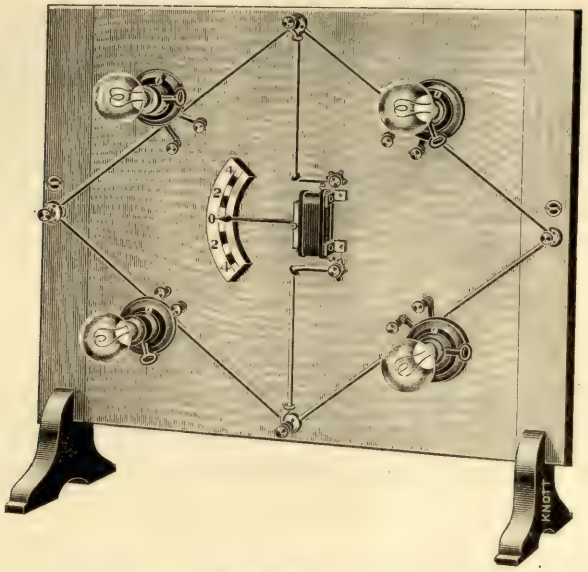
No. 94-455

94-455 HYDRODYNAMIC WHEATSTONE BRIDGE, for a study of the principles involved by measurements of resistances by the Wheatstone's Bridge method, using Fall of Hydraulic Pressure as an analogy to electromotive force. On a polished wooden base board is mounted a system of tubes connected to form a Wheatstone's diagram. In the "arms" are reducing valves analogous to resistances. Pressures in the various arms are indicated by the manometers. In the "bridge" is a pressure indicator analogous to the galvanometer.

By connecting to one of the nipples noted in the illustration and allowing a flow of water through the apparatus, the fall of pressure through the different arms may readily be noted. By regulating the reducing valves in these arms, a balance may be secured when no indications of pressure can be noted in the "bridge." The pressures in the arms will then be noted in the manometer.

The didactic value of this apparatus will readily be noted. The construction is substantial, results possible are positive, parts are carefully fitted and handsomely finished.

Complete as illustrated . . . . . Duty Free **$34.50**



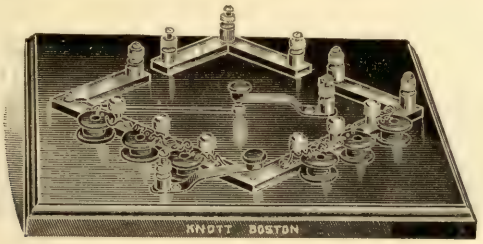
No. 94–460

94–460 DEMONSTRATION WHEATSTONE BRIDGE, for a study of Fall of Potential and demonstration of the principle of a Wheatstone Bridge.

This apparatus consists of a vertically-mounted board to which is attached the Wheatstone Diagram. In the "arms" are connected incandescent lamps. In the "bridge" an indicating galvanometer. Binding posts are provided for connecting resistances in shunt with the lamp. By varying the resistances a point of same potential may be secured.

As a companion instrument to No. **94–455** Hydrodynamic Wheatstone Bridge, demonstrations of Fall of Potential as utilized in the Wheatstone Bridge are simply and clearly made.

Complete as illustrated with incandescent lamps . . . . . Duty Free **$26.00**

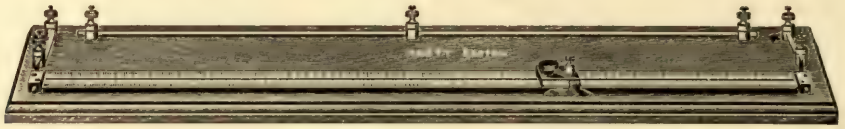


No. 94–470

94–470 WORKING DEMONSTRATION WHEATSTONE BRIDGE, DIAMOND FORM. The merit of a Wheatstone Bridge that may be used equally as well in demonstration as in laboratory practice will at once be recognized.

The instrument illustrated is constructed so that the arms are arranged as the Wheatstone Diagram. In addition in each of the "ratio arms" are coils of 1, 10, and 100 ohms. The "balance arms" are provided with gaps each with non-detachable binding posts, one pair for the known and the other pair for the unknown resistance. Non-detachable binding posts and key are provided for battery and galvanometer circuits. All parts of this instrument are well made. They are carefully fitted and the instrument is guaranteed to give good satisfaction **$5.80**

SLIDE WIRE WHEATSTONE BRIDGES



No. 94–480

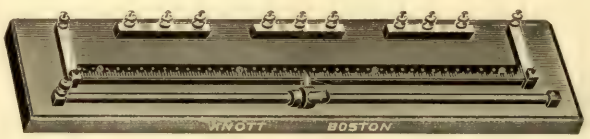
94–480 WHEATSTONE'S STANDARD METER SLIDE WIRE BRIDGE. In this design, especially adapted for students' laboratory experiments, we furnish an excellent bridge at a reasonable price. Heavy copper leads, non-detachable binding posts, manganin wire, improved positive sliding contact key, mounted on polished hardwood base **$3.35**

94–482 WHEATSTONE'S BRIDGE, after Millikan & Gale's "A Laboratory Course in Physics," Experiments 32 and 33 . . . . . **2.25**

No. 94–490

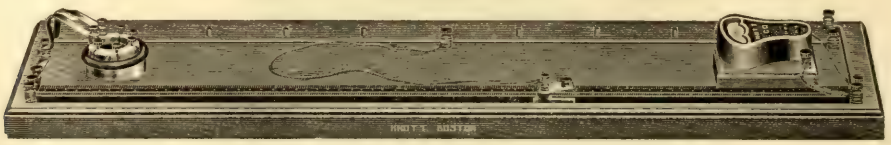
94–490 WHEATSTONE'S HALF METER BRIDGE, HARCOURT FORM. This bridge is in construction similar to No. **94–480,** and in quality fully its equal.

To economize space as well as facilitate its use, it is made in half meter length, but so designed as to carry the full meter length of wire. In accuracy, therefore, it compares favorably with the full-length bridge **$2.80**



No. 94–495

94–495 HALF METER WHEATSTONE-CAREY-FOSTER BRIDGE. Extra heavy brass strips, non-detachable binding posts, improved sliding knife edge contact key, improved scale mounted on highly polished base **$9.00**



No. 94–500

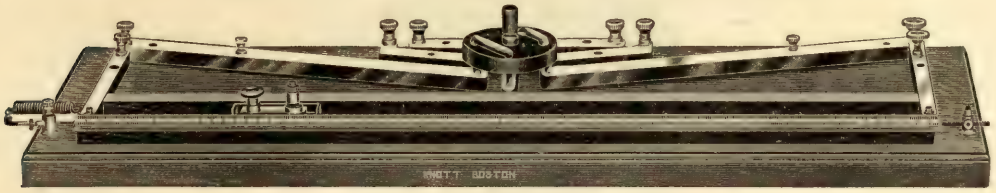
94–500 COWEN COMBINATION BRIDGE. This Bridge was first constructed for the Boston High Schools, but is now generally recognized as a Wheatstone Bridge having unusually valuable educational features.

It is provided with an especially designed resistance box set in the base, and furnished as a part of the instrument. A horizontal D'Arsonval Galvanometer No. **93–195** is also mounted on the base. Thus it may be seen that a complete measuring unit combining bridge, resistance box, and galvanometer is furnished as a unit system. The necessity, therefore, of all outside connections except those from the battery and unknown resistance is entirely avoided. The permanent connections to the resistance box and the galvanometer are made on top of the bridge in such form that the direction of the current can be most easily traced.

Combination Bridge, Box, and Galvanometer **$22.50**

94–502 COWEN COMBINATION BRIDGE and Box without Galvanometer **15.00**

TRANSFORMING AND INTERRUPTIVE APPARATUS



No. 94–525

94–525 **THE UNIVERSITY SLIDE WIRE BRIDGE,** adapted for measuring resistances with low E. M. F. where the plug form of Resistance Box would be useless. Provided with both mercury cup and binding post contact, the Lattimer-Clark Commutator, tension spiral for bridge wire, contact with rack and pinion and fine adjustment, locking device for holding the contact at any desired point.

Connecting bars of large cross section, tested for uniform density. Mercury cups of ½ inch diameter with bottom finished to give perfect contact.

Binding posts of large size, provided for each gap in addition to the mercury cup.

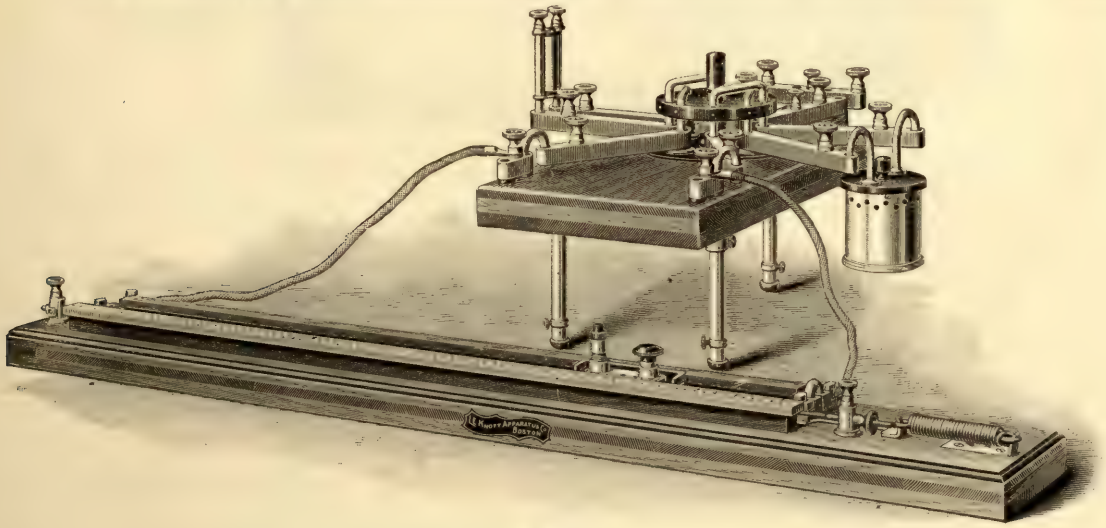
Four gaps are provided for ratio coils and extension coils, which are also available for inserting coils in the conventional Wheatstone Bridge arrangement. The commutator may be removed, leaving available two extra gaps which may be required in special work.

Spring Tension insures uniform tension on the resistance wire. Wire supplied for this work will be manganin unless otherwise specified.

Slider. Combination Rack and Pinion and fine adjustment with push button locking device, makes a most satisfactory method of obtaining a sliding contact. The contact is entirely enclosed to overcome any possible thermo-electric disturbance due to the presence of the hand of the operator. The scale is engine-divided with vernier reading to tenths of a millimeter.

Base is of three-ply mahogany to prevent warping, oil finished.

An instrument of the highest accuracy and convenience, substantially and beautifully finished . . . **$75.00**



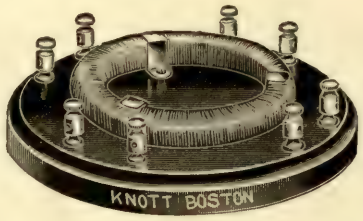
No. 94–535

94–535 **THE UNIVERSAL CAREY-FOSTER BRIDGE.** The Carey-Foster method is recognized as the one suited to the most rapid and accurate work in electrical measurements. It is, in fact, the method which we have found in our own testing department to give not only the most reliable results, but one which permits the largest number of measurements per unit of time.

The Bridge above illustrated is substantially the one used in our own electrical measurements, and is therefore adapted to a very wide range. The low resistance swinging arms, the mercury contacts, the sliding bridge, the essential features of which are made substantially as in instrument No. **94–525,** the micrometer movement on the contact, the heavy insulated low resistance copper leads, the Carey-Foster reversing key, combine to give this instrument a place in high-grade electrical measurements not filled by any other form.

The accuracy with which this Bridge is made will perhaps be appreciated when it is known that even the ½-inch copper lead wires and the heavy copper buss bars are carefully tested and adjusted before being set up in the instrument.

The **bases** are made of three-ply mahogany finished in oil; the finish on the entire instrument is in keeping with that of a thoroughly high-grade, accurate, scientific instrument **$110.00**



No. 95–10

95–10 FARADAY'S RING AND DEMONSTRATION TRANSFORMER. This simple apparatus is designed for study of the principles and laws involved in self and secondary induction; also the applications of these laws to the step-up and step-down transformer.

It consists of a closed magnetic circuit within a coil of wire which is tapped and brought to binding posts, dividing itself into four coils of an equal number of turns. The ring and binding posts are mounted on a neatly finished, polished base, making a compact, well worked out instrument in which the ratios of transformation on a unit of voltage are as follows: —

1:1; 1:2; 1:3; 1:4; 2:1; 2:3; 3:2; 3:1; 4:1 . . . . . **$3.25**

95–15 INDUCTION COIL, after Millikan & Gale's "A Laboratory Course in Physics," Experiment 36.

This is a simple coil of wire wound on a brass spool **1.10**

Figs. 1 2 3 4 5 6

Figs. 7 8 9

No. 92–130

92–110 GILLEY INDUCTION COILS, Figs. **1** and **6**, mounted with binding posts. These coils are described on page **426** and are recommended for general experiments in Induction . . . . Per set of two **$1.40**

92–115 SOFT IRON U-SHAPED CORE, Figure **3**, for study of bi-polar electro-magnets . . . . . Each **.20**

92–117 SOFT IRON ARMATURE, Figure **2**, for use with the above core in the study of electro-magnets. Each **.10**

92–120 SOFT IRON CORE, Figure **5**, single, for the study of electro-magnets . . . . . Each **.10**

92–122 PAIR OF HALF-ROUND CORE PIECES, Figure **4**, for mapping the lines of force in an electro-magnet . . . . . Per pair **.15**

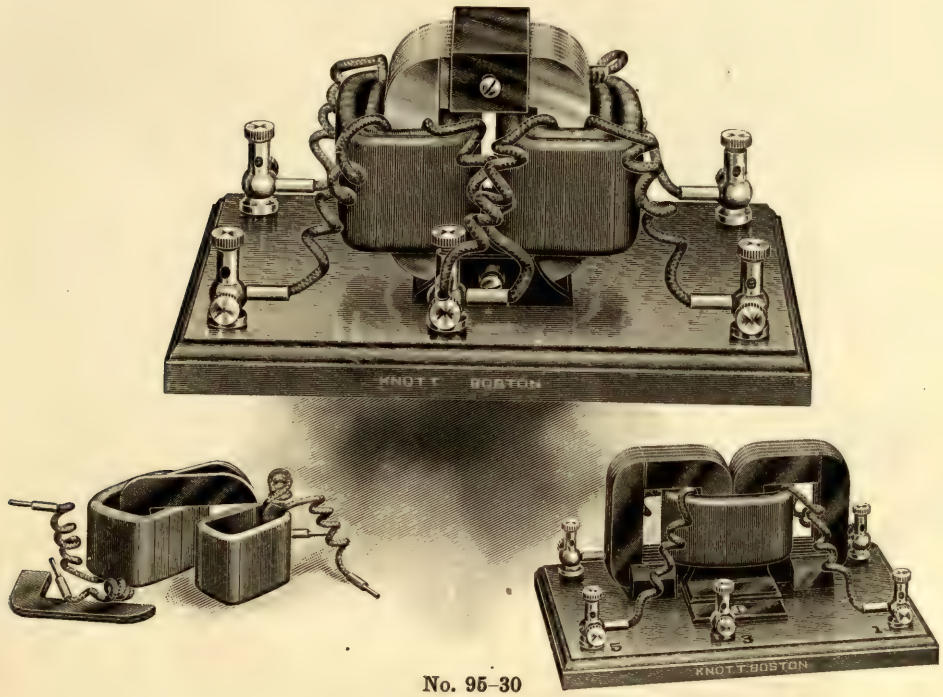
92–125 PAIR OF SLOTTED CARDBOARDS, Figure **7**, for mapping lines of force . . . . . Per pair **.08**

92–130 COMPLETE GILLEY INDUCTION OUTFIT, supplied in box with direction sheets **2.00**

No. 95-30

THE IMPROVED EDUCATIONAL DISSECTIBLE TRANSFORMER

ANY VOLTAGE UP TO 115



No. 95-30

Patents Pending

In the designing of this Transformer we have had in mind an instrument resembling as closely as possible the commercial instrument. In order to make it of the greatest practical use in the laboratory and at the same time serve to teach all of the fundamental forms of Transformers, the dissectible feature is, of course, essential, since a school can hardly afford to buy as many different Transformers as there are types in commercial use.

The instrument which we have produced will be found of the greatest use in demonstrating the principles and laws involved in **self** and **secondary induction,** also the application in commercial work of the **step-up** and **step-down transformer.**

CONSTRUCTION. In form and in methods of construction, the regular commercial instrument as used in lighting and power systems has been followed: — laminated core, taped coil, every feature designed to give the greatest efficiency and greatest durability.

The **dissectible feature,** which enables the student to take the instrument apart, examine and test each part separately, is obtained as follows: —

The **core** is of punchings made from the best electrical sheet iron, punchings arranged in groups of 10, each group being held together by riveting, for convenience in assembling. **Primary coils** are taped and supplied with convenient leads. **Secondary coils** are taped and supplied with leads. These features enable the instrument to be assembled either as a Faraday Ring, Auto Transformer of the shell type, an Auto Transformer of the block or iron-clad type, a Primary and Secondary Transformer of the shell type, a Primary and Secondary Transformer of the block type.

RANGES IN VOLTAGE. The ratios of the primary to the secondary coils are such that a great variety of transformations may be had. If the primary circuit is 110 volts, the voltages drawn from the secondary in various combinations (fully illustrated by diagrams furnished with each instrument) are 7, 15, 30, 60, 220, 235, and 255 volts. Other ranges may be obtained by using a different voltage in the primary line, the ratios of transformation in each case being as above indicated.

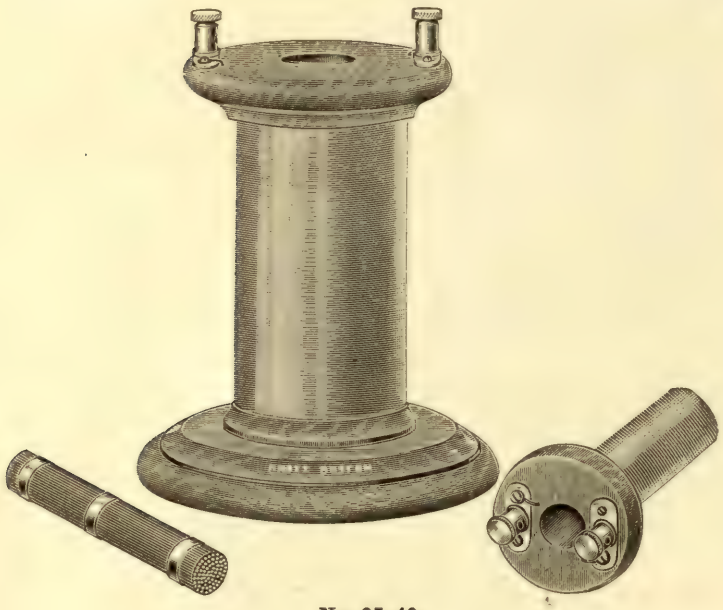
For convenience in use the instrument is mounted on a mahogany base with six double binding posts as illustrated.

The instrument serves to teach effectively: —

1. The influence of iron in the core.
2. The magnetic hysteresis.
3. Eddy Currents.
4. Magnetic density.
5. Self-Induction.
6. Back electro-motive force, and many other fundamental principles in alternating current practice not possible with any instrument heretofore offered. Full directions with descriptive diagrams will be supplied with each transformer.

Complete with full equipment for teaching all of the points above mentioned **$11.25**

PRIMARY AND SECONDARY COILS



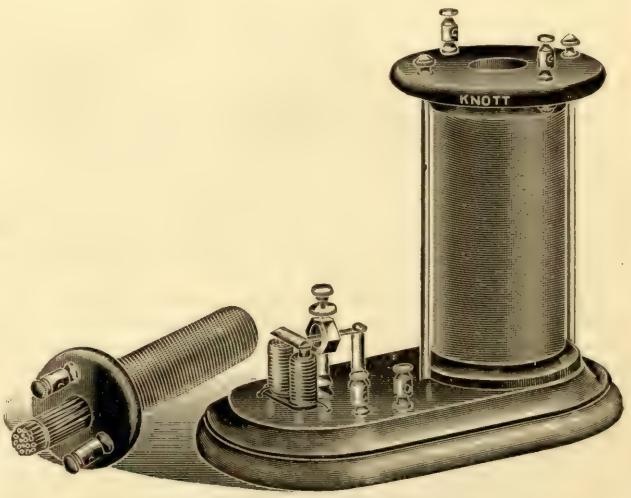
No. 95–40

95–40 LARGE PRIMARY AND SECONDARY COIL, for the study of current induction. This form, with its primary 6 inches by 1¼ inches and its secondary 2½ inches by 5 inches, must not be confused with the smaller types on the market. We have desired in this instrument to offer the teacher an instrument capable of efficient positive results. This can be secured in a satisfactory manner only by using a large number of windings on the secondary circuit. The wire in each circuit is mounted on separate hardwood spools, and the secondary is mounted on a neatly polished hardwood base. To insure greater rigidity we have added two brass rods connecting the secondary to the base (see illustration below). The wire used is silk covered, and binding posts are neatly polished and lacquered. The soft iron core supplied with the instrument consists of a bundle of soft iron wires tightly moulded by bands to form a nearly solid rod.

Primary and Secondary Coil complete with iron core **$7.50**

95–45 LARGE PRIMARY AND SECONDARY COIL, similar to above, but provided with vibrator mounted on same base with coil. This vibrator is of the simple electromagnetic type and gives positive interruptions to the current, illustrating the simple induction coil. This instrument is of substantial construction, and all parts are finely polished and finished.

Complete as illustrated **$10.50**



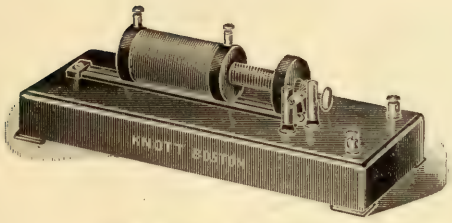
No. 95–45

95–50 MAKE AND BREAK INTERRUPTER. It is frequently desired to attach a Make and Break Interrupter to an unmounted primary and secondary coil. The type which we furnish is the same as illustrated on the base of the Primary and Secondary Coil No. **95–45**.

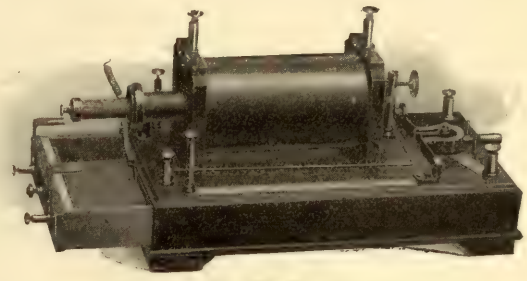
The parts are mounted on a neat wooden base ready for attachment to the terminals of the secondary **3.00**

INTERRUPTING WHEEL. See No. **90–460.**

INDUCTION COILS



Nos. 95–75 to 95–80



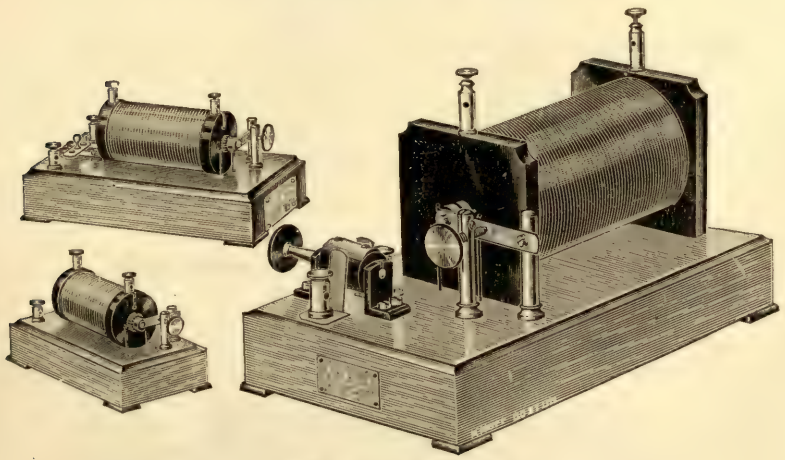
No. 95–95

95–75 DEMONSTRATION INDUCTION COIL. This type of coil is of value in the study of the office of the primary in induction coil construction. Both primary and secondary are mounted on a polished mahogany box, but the mounting is designed so that the secondary may be adjusted to enclose varying amounts of the primary.
This instrument is handsomely finished, all brass parts polished and lacquered, and will give a ¼ inch spark **$5.00**

95–80 ——, same as above, but calculated to give a ½-inch spark **8.25**

95–95 DEMONSTRATION DISSECTIBLE RUHMKORFF COIL. This coil is constructed so that all essential details of a commercial Ruhmkorff coil may be shown as units and in their relations to the rest of the instrument. Thus the condenser is mounted in a drawer slide. Connections with the secondary are secured through binding posts. The primary may be dissected and taken from the instrument. The make and break and core are of special design calculated to teach the principle, and all connections are fully in the open and may readily be noted at a glance . . . . . Duty Free **37.50**

RUHMKORFF COILS



Nos. 95–125 to 95–140

Our small types of Ruhmkorff Coils up to 1-inch spark are constructed for us by a prominent European manufacturer. They are of standard quality designed for elementary work.

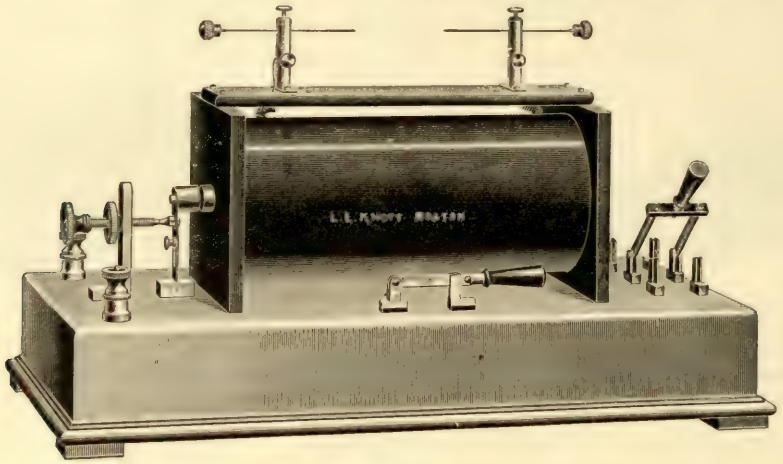
Ruhmkorff Coils with a capacity of 2 inches (see next page) are constructed by us in our own factory. We are, therefore, enabled to furnish a product superior in quality to that ordinarily furnished of European make. We secure a greater efficiency and are enabled to place in the hands of the buyer a more finished instrument. The parts of these coils are of the best proportions to give the maximum efficiency and preserve symmetry. Only the best quality of material is used in construction, and all parts are handsomely finished.

We are enabled to guarantee our coils up to their full capacity and warrant them against faulty construction.

EUROPEAN COILS

95–125 RUHMKORFF COIL, capacity ⅛-inch spark **$3.85**
95–130 ——, capacity ¼-inch spark **4.90**
95–135 ——, capacity ½-inch spark **7.50**
95–140 ——, capacity 1-inch spark **21.00**

THE "NEW LINE" INDUCTION COILS



Nos. 95–175 to 95–210

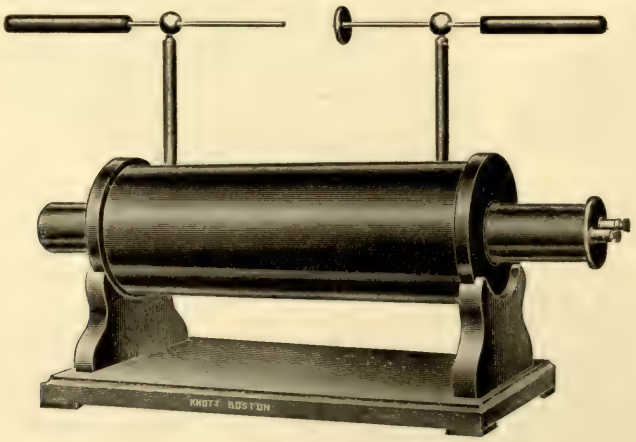
Because of the great improvements in Induction Coil design during the past three years, it is with especial pleasure that we call your attention to our series, ranging from 2 to 18-inch discharge.

These coils are constructed according to the latest and best high-tension data. The rigorous demands of X-Ray and Wireless work have rendered valueless coils constructed according to formulæ previously used.

The entire construction of the coil is based on the requirements of heavy discharge rather than length of spark. This is obtained by the use of exceptionally heavy primaries with, of course, the best possible insulation. Every feature has been worked out with the greatest care looking towards the building of a coil which cannot be broken down and which will give the desired results on comparatively low battery power, and in coils designed for use on 110-volt current which will take the rated voltage and amperage without danger.

TESTING. Each coil is subjected to a rigorous test with an overload of 100% to insure against breaking down with ordinary usage.

95–175	**NEW LINE INDUCTION COIL,** guaranteed discharge 2 inches	**$37.50**
95–180	——, same as above, guaranteed discharge 4 inches	**55.00**
95–185	——, guaranteed discharge 6 inches	**75.00**
95–190	——, guaranteed discharge 8 inches	**100.00**
95–195	——, guaranteed discharge 10 inches	**120.00**
95–200	——, guaranteed discharge 12 inches	**145.00**
95–205	——, guaranteed discharge 16 inches	**200.00**
95–210	——, guaranteed discharge 18 inches	**240.00**



No. 95–230

LIQUID INTERRUPTING INDUCTION COIL, for a 110-volt current. In connection with our "New Line" Induction Coils above listed we have worked out an instrument for use on the 110-volt current, especially designed to withstand the entire current from Liquid Interrupter No. **95–252.** It gives a heavy discharge, admirably suited for Wireless, X-Ray, and general induction coil experiments. It may be used with safety, as these coils are designed not to burn out on a 110-volt current.

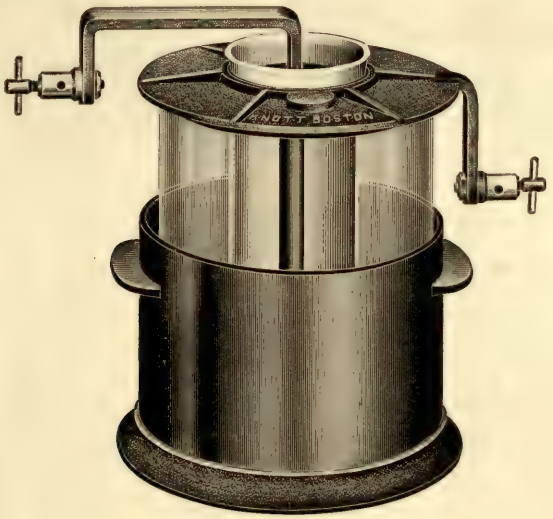
The 7-inch discharge which these coils are designed to give is such as is found most satisfactory for general all-round work in X-Ray and Wireless experiments.

95–225 LIQUID INTERRUPTING INDUCTION COIL, complete with Liquid Interrupter **$74.90**

95–230 ——, same as above, without Interrupter **60.00**

We are listing both coil and interrupter together for the reason that it is somewhat easier to adjust the interrupter to the coil if both are ordered at one time. This adjustment, however, is not absolutely necessary, as a careful record is made of each coil and the adjustment can be made at a later date.

THE ELECTROLYTIC INTERRUPTER



Nos. 95–250 to 95–252

Patents Pending

The difficulty with Electrolytic Breaks heretofore used has arisen largely because of the failure of the manufacturers to adjust the size of the gas tube to the line voltage and the amperage which is to be drawn from the break. This difficulty has been fully recognized and satisfactorily met.

We can supply our new design of Electrolytic Interrupter for any voltage and amperage desired. The two forms selected as being most generally serviceable are listed below and are rated according to the Induction Coil capacity with which they are to be used. Please note that they will operate on a direct or alternating current.

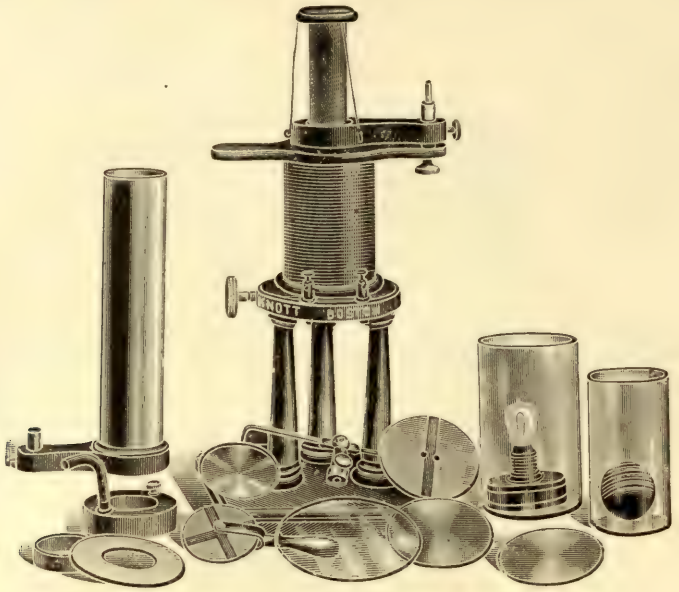
CONSTRUCTION. Our Interrupter contains a porcelain cylinder in which the size of the opening is carefully adjusted to the amperage of the current to be drawn. In order to avoid breakage this cylinder is carried on a lead shelf, being part of the inner lead cylinder.

The terminals, as will be noted in the cut, are carried well out on the ends of the long lead bars, bent over and beyond the top of the instrument so as to reduce the objectionable corrosion that is unavoidable when the terminals are above the jar and subjected to the action of the acid fumes thrown off when the Interrupter is in operation.

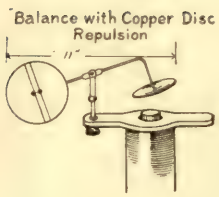
METHOD OF COOLING. A substantial iron receptacle is provided which acts as a radiator and serves to keep the liquid from overheating. This receptacle also serves to protect the table, floor, or other apparatus in case of accidental breaking of the acid jar.

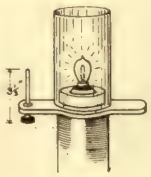
95–250 ELECTROLYTIC INTERRUPTER, type A, for coils from 4 to 6 inch spark **$13.80**

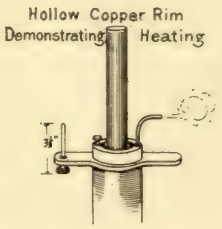
95–252 ELECTROLYTIC INTERRUPTER, type B, for coils from 7 to 12 inch spark **14.90**

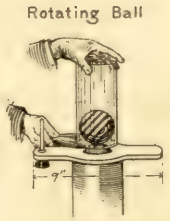


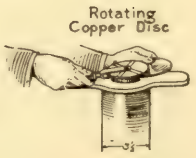
No. 95–260











95–260 ELECTRO-DYNAMIC APPARATUS. This apparatus has been designed for the purpose of showing the repulsion and rotation effects produced by an alternating current. It is designed to operate on a commercial circuit of 110 volts, the alternating current being recommended. It may be used, however, satisfactorily on the direct current if used in connection with our Electrolytic Interrupter No. **95–252.** The apparatus is complete, covering a full set of parts for performing a most instructive series of experiments. A few of these we note herewith: —

Diaphragm made to vibrate in unison with the alternations of the current so as to give out a distinct tone.

Repulsion of a copper disc held in proximity to the iron core on the balance arm.

The rotation of the copper disc, caused by the revolving field.

The rotation of an iron disc, made in part of copper.

The rotating ball. A copper ball, placed over the exposed end of the iron core and one-half of the core covered with a copper disc, will rotate. By floating the ball in a jar of water, the rotation becomes rapid.

Lighting of an electric lamp by means of the pulsations given out from the iron core, this being accomplished through the glass jar.

The suspension of a heavy metal ring placed around the iron core.

The comparative repulsion of copper and aluminum rings.

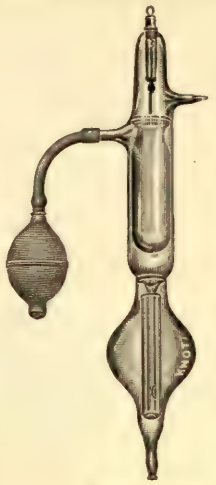
Heating effect in a copper ring, shown by the boiling of a liquid.

These and many other experiments may be performed with the above apparatus. Their striking character has caused the outfit to be extensively used as a lecture table set.

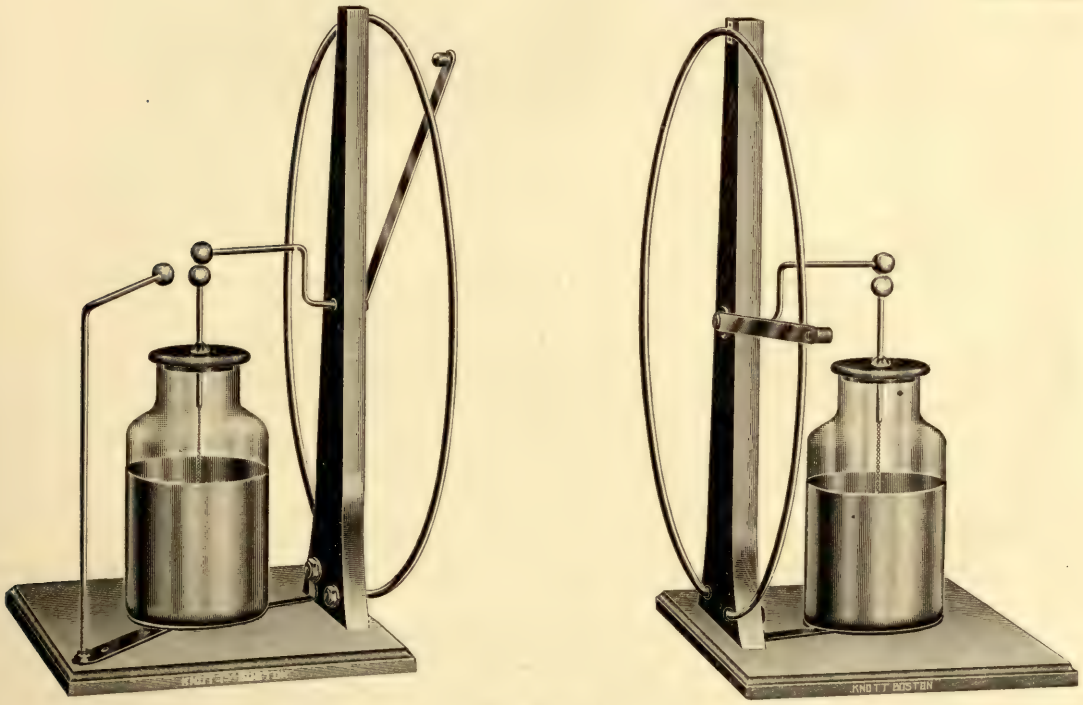
Complete directions for operating and performing many experiments are furnished with the outfit.

Duty Free **$55.00**

95–300 OZONE GENERATOR TUBE, a simple glass therapeutical device known as an Ozone Generator Tube. This instrument has been listed, as it has several features of educational value. In operation the central terminal is connected to a source of High Frequency Current which will fill the air chamber surrounding the central vacuum tube with a fine brush discharge, instantly transforming a portion of the Oxygen of the air into Ozone, which is readily detected by the odor. If desired, Oil of Pine, Starch Solution, or similar Ozone detecting chemicals may be placed in the upper chamber of the device and the air forced through them by simply pressing the bulb furnished. The instrument being made entirely of glass, all operations are clearly visible **$12.50**



No. 95–300



No. 95–310

95–310 SEPARATELY MOUNTED RESONANT LEYDEN JARS, a pair of jars mounted on independent stands, each being fitted with an adjustable discharging circuit, for demonstration of: —

1. Resonance between Electrical Circuits.
2. The Oscillatory Character of the Condenser Spark.
3. Tuning as applied to so-called High Frequency Circuits, Wireless Telegraphy, etc.

They make an impressive and instructive lecture table outfit. In operation one of the jars should be charged by means of a static machine or induction coil, and at each discharge a simultaneous spark will be obtained from the other jar providing that its loop is adjusted to the same position as the loop on the first. Changing the size of the loop on either of the jars without altering the other will throw them out of tune, and the charge on one will be much less than on the other. When in tune the two parts of the outfit may be removed a considerable distance apart, thus showing in a very clear manner the wonderful sensitiveness of resonant circuits.

The outfit is usually equipped with one-quart Leyden Jars, but jars either larger or smaller may be used, if at hand, thereby greatly increasing the educational value of the device, for it can be shown that to obtain resonance the value of the condenser times the inductance or loop must be the same; i. e., a large jar discharging through a small part of the loop of conductor will energize the other or smaller jar through a larger part of its circuit, etc.

Separately Mounted Resonant Leyden Jars, complete as illustrated **$14.50**

HIGH FREQUENCY

The practical applications of high frequency currents during the past few years have assumed such proportions that instruction in this branch of applied electricity should be included in every scientific course. Starting with its use in therapeutics, high frequency currents are now on a mathematical basis, and practically applied in wireless telegraphy, wireless telephony, etc. The varied and striking phenomena associated with high frequency apparatus differ in no way from the ordinary inductive experiments as performed with the old appliances, except as to degree, the only difference between high frequency currents and alternating currents being in the rate of the alternations. But this difference greatly increases the value of high frequency currents as an educational agency. For example, in order to show the stepping up of voltage by induction, from one coil to another, close-wound coils of large number of turns were used in the old method, while in high frequency the same ratios of transformation are obtained with coils of open construction and few turns, enabling the observer to see all the effective parts of the apparatus.

Experimental work with high frequency currents has been impeded by the lack of well-designed apparatus in marketable form. The coils which are listed on the following pages are the results of fifteen years' experience in the construction of high frequency apparatus, the first coil of this general type being built by us in the early days of high frequency work. It has taken years of careful study, however, to learn how best to combine the elements embodied in these instruments so as to produce a compact, safely handled coil giving adequate power with a range of adaptability which would especially fit it for a scientific study of high frequency phenomena.

We are offering these coils in two types, — the larger laboratory type being a bi-polar machine giving a continuous 12-inch discharge and provided with two oscillating coils; the smaller machine is of the single pole type, giving a 10-inch continuous discharge, and mounted in compact form for easy, safe storage and transportation, the entire instrument folding into a small space forming its own carrying case with dimensions of 16¾ by 8½ by 9⅝ inches.

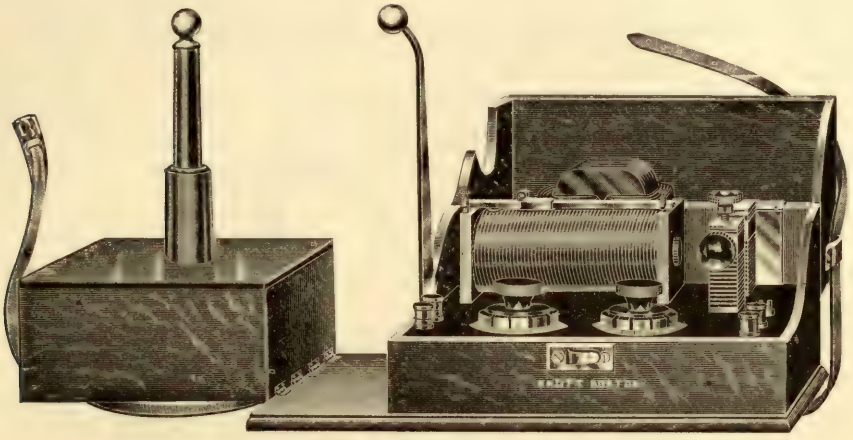
Both of these instruments are self-contained, and may be connected directly to lighting circuits. Each coil is guaranteed against "breakdowns" and "burn-outs." Each will deliver at the will of the operator a minute spark or a powerful discharge. This powerful discharge, however, unlike the large induction coils, is not dangerous to the experimenter, one of the peculiarities of high frequency coils being their inability to shock or destroy the nervous system.

The apparatus required in addition to the coil for the study of the phenomena of high frequency currents is simple and easily operated. For the convenience of teachers, we have listed under No. **95–375** apparatus sufficient for performing many spectacular and instructive experiments, many of these experiments being outlined on the third page following.

No. 95–325

UNI-POLAR HIGH FREQUENCY COIL

TEN-INCH CONTINUOUS DISCHARGE



No. 95–325

This instrument is a most striking outfit for general lecture work and for exhibition. It is built on lines that have proven successful in the highest grade instrument construction. Not only does its peculiar compact design protect the working parts when not in use, but it also affords an instrument that is readily transportable from place to place. Although when folded it occupies 16¾ × 8½ × 9⅝ inches, when open, it is not only large, but all the vital parts are held at a considerable distance apart, so that a very large amount of energy can be handled without overloading or subjecting the various parts to an undue strain. The instrument is entirely self-contained and after being connected to the lighting circuit by means of a cord and plug, it is ready for use.

We desire to call particular attention to the construction of this coil. Its design has been the result of careful investigation, and the expenditure of a great amount of time and money. We believe that there has been attained a perfection not reached by any instrument of its class. It comprises no new or untried parts or material. We have watched its development and operation for several years, and when thoroughly convinced of its merits, utility, and "standing-up" qualities, made arrangements with its inventor for its sale in educational institutions. We are enabled to fully guarantee this coil against accidental "break-downs" and against "burn-outs."

Designed for alternating current, complete with carrying strap, connecting cords and Edison plug, and with pamphlet descriptive of care and use **$200.00**

95–330 DIRECT CURRENT UNI-POLAR HIGH FREQUENCY COIL, same as above, but provided with a carefully-designed Interrupter embodied as a part of the outfit. When so designed, nearly all the experiments illustrated on the second page following may be demonstrated. In several of the experiments, however, it will be found that the results are not quite as striking as with the alternating current machine.

Designed for direct current, complete with carrying strap, connecting cord and Edison plug, and with pamphlet descriptive of its care and use **210.00**

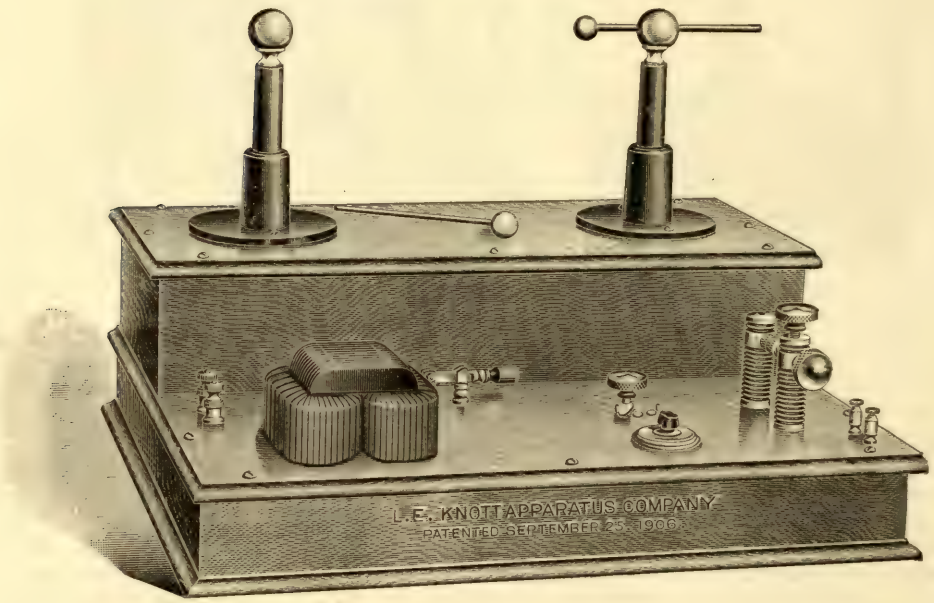
Showing Coil Folded

No. 95-340

BI-POLAR HIGH FREQUENCY COIL

TWELVE-INCH CONTINUOUS DISCHARGE

Designed for Alternating Current



No. 95-340

95-340 BI-POLAR HIGH FREQUENCY COIL. This coil is designed to furnish a powerful high frequency discharge, suitable for X-Ray work and general experiments requiring high voltage. It is of ample proportions and entirely self-contained. It is of the bi-polar type, i. e., each terminal is active and throws off an abundance of energy when in operation. The instrument is fitted with an experimental circuit for demonstrating the laws and performing the many interesting and instructive experiments pertaining to high frequency phenomena.

Our coils are built for service, only the best of material being used in their construction. They are built on lines that positively avoid the danger of expensive "break-downs," such as are met with in the old style of induction coils. Each coil is fully guaranteed against mechanical and electrical imperfections.

The instrument is finely finished throughout and is furnished in a polished mahogany case. All metal parts are neatly polished and lacquered.

Complete with connecting cord and Edison plug and with complete directions for care and use . . . **$140.00**

95-375 HIGH FREQUENCY PHENOMENA APPARATUS. For the convenience of teachers who desire to give a course in high frequency currents we have designed apparatus capable of performing all the experiments outlined on the following page and many others incapable of adequate illustration. This line of apparatus is well made, and finished and guaranteed satisfactory in every respect. All the instruments have been tested with the previously listed coils and the instructive and interesting results obtained have fully warranted a place in our catalogue.

High Frequency Phenomena Apparatus sufficient for performing all the experiments outlined on the following page. In neat wooden case but without X-Ray Tube **35.00**

HIGH FREQUENCY PHENOMENA

ILLUSTRATING TWENTY-FIVE OF THE MANY POSSIBLE EXPERIMENTS

Melting wire held in hand

1

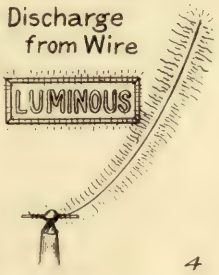
Brush Discharge from Hand

2

Brush Discharge Ozone Generator

3

Discharge from Wire

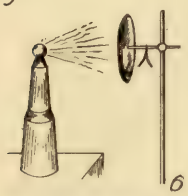


4

Molecular Bombardment

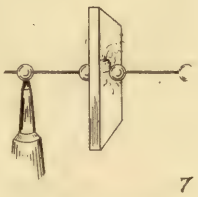
5

Transformation into Static Electricity



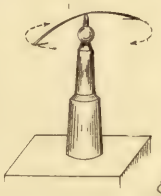
6

Destruction of Dialectric



7

Electric Whirl

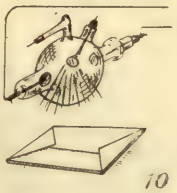


8

Effect of Air Blast on Discharge

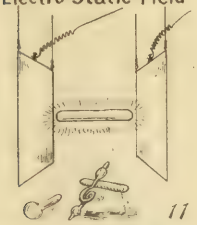
9

X-Rays Radiography Fluoroscopy



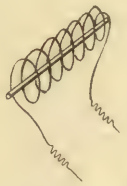
10

Lighting Vacuum Tube without connection Electro Static Field



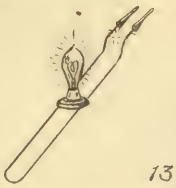
11

Hysteresis Heating Iron



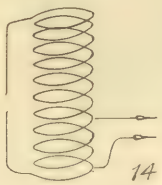
12

Self Induction Marked Drop in Voltage



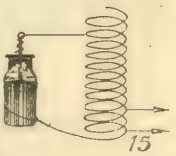
13

Stepping up Voltage with forced oscillations in self induction helix



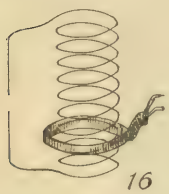
14

Resonance in Helix



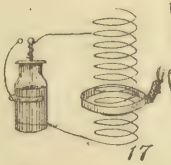
15

Primary and Secondary Induced Forced Currents



16

Primary and Secondary Induced Resonant Currents

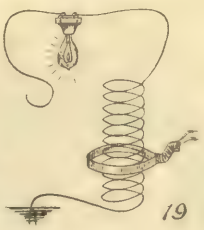


17

Lighting Commercial Lamp through Body

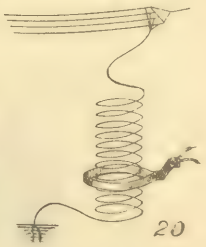
18

Lighting Lamp on one wire



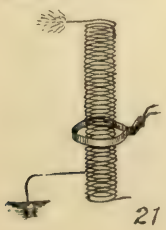
19

Wireless Telegraphy



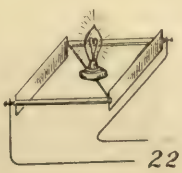
20

High Voltage Resonant Helix



21

Surface Resistance

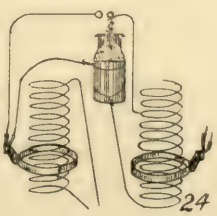


22

Ultra Violet Light Fluoresence

23

Very High Frequency



24

Radiation through Dialectric

25

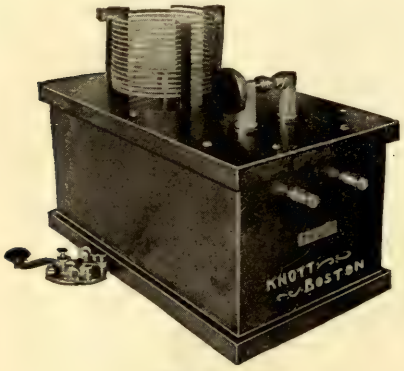
COMMERCIAL WIRELESS APPARATUS

The educational value of Wireless Telegraphy and High Frequency Apparatus cannot be overestimated. Holding the attention of the student and scientist alike with a wonderful fascination, it has been the means of awakening an interest in school work where all other devices have failed.

It is not unusual today to hear pupils in the elementary grades speaking in a comprehending manner of wave fronts, vibrations, resonance, attuned circuits, potentiometers, variable condensers, and like subjects and phenomena, that a few years ago were understood only by advanced students of science. It can hardly be realized that students in the grammar schools have been enabled through their interest in this class of apparatus to so master the subject as to be capable not only of designing and building working outfits, but also of reaching such a degree of proficiency in operating them as to be employed as expert operators in commercial stations.

Wireless apparatus should be installed in every school taking up the study of Physics, for it will be found to be the one set of apparatus in the laboratory that will hold the students' attention. Clubs will be formed, and the students will take the greatest interest in getting into communication with neighboring schools fitted with apparatus, and one and all will endeavor to excel in proficiency and understanding of the subject.

The installation of apparatus is extremely simple, requiring but little more thought and time than the installation of an ordinary telegraph instrument. In many sections of the country the apparatus is interesting in that it furnishes a ready means of obtaining standard time which is given out daily from the important government stations. So much apparatus of purely amateur design and construction has been offered for school work that we feel that the success of the instruction in this field has been seriously handicapped. For this reason we have decided to offer only standard types of commercial instruments, built by manufacturers of the widest experience in installing commercial outfits.



No. 95-400

95-400 COMPLETE SENDING OUTFIT. This is a compact outfit comprising Transformer, Condenser, Helix, Spark Gap and Key mounted in and on a finely finished mahogany cabinet. It is shipped ready for use and has but to be connected to any convenient source of 110-volt alternating current and a suitable antenna.

Complete as above described **$40.00**

No. 95-405

95-405 COMPLETE RECEIVING SET. This is a combination of instruments mounted in a well-finished mahogany cabinet with hinged cover. This set includes a Ferron Detector, a Receiving Transformer, a Fixed Condenser, a Rotary Variable Condenser, and a 2000-ohm Telephone Head Set. Binding Posts are provided for antenna, ground, and receiving connections.

The compactness, accessibility and efficiency of this instrument will appeal to any one interested in the subject.

Complete Receiving Set **$37.50**

SEPARATE WIRELESS UNITS

No. 95–410

We list below a line of high-grade separate units for the benefit of those who are already partially equipped or who may wish to construct for themselves a part of their wireless apparatus. The design of the units is of the very latest commercial types and such as will appeal to those desiring to do high-grade work in the wireless field.

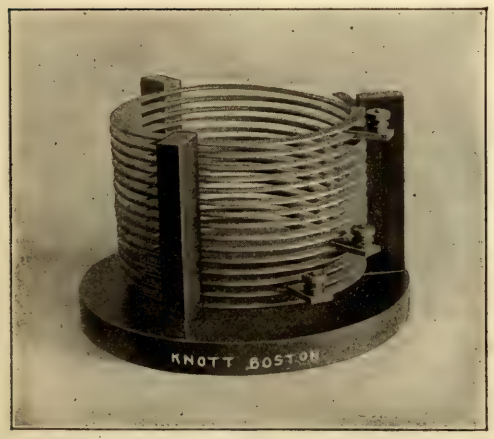
SENDING APPARATUS IN SEPARATE UNITS

95–410 TRANSFORMERS. High efficiency, high power, low heating factors, and reliable service. Each instrument is mounted in mahogany cabinet, the secondary sections being instantly removable without injuring the transformer. The primary may also be drawn from the tube without interfering with the secondary.

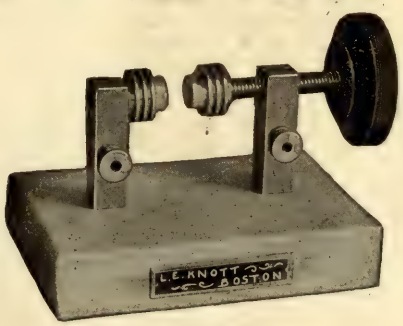
	a ¼	b ½	c 1 K. W.
Each	$33.00	49.00	67.00

95–415 HIGH POTENTIAL CONDENSERS. Each condenser is mounted in a box with separate connections brought out from each unit so that the capacity may be varied by connecting in various sections. This form of condenser will save an enormous amount of energy which is frequently lost in the condenser system. It will conserve the great power of our transformers as no other condenser can. With this type of condenser the efficiency of a station is often doubled.

	a ¼	b ½	c 1 K. W.
Each	$9.80	19.75	41.00



No. 95–420



No. 95–430

95–420 HELIX. This helix is the one employed in No. **95–400** Transmitting Set. It is simple and rugged in construction, of unusual efficiency, employing as it does edge-wise wound copper strips. The base is of finished mahogany; supported on hard rubber. Three clips are provided for varying the degree of coupling . . **$5.50**

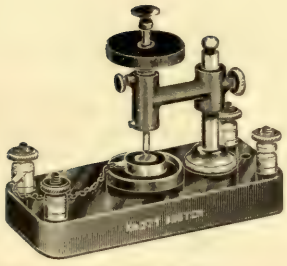
95–425 OSCILLATING TRANSFORMER. Our ¼ ½ and 1 K. W. sending inductances are of the inductively coupled type, having the right amount of coupling to produce a high defined wave and perform close tuning at the receiving station. The primary is of copper ribbon wound spirally. The secondary is of copper ribbon wound on especially prepared drums. Both circuits have variable inductances which insure absolute resonance between the two circuits, insuring the radiation of a greater amount of energy in the form of waves, instead of the energy being wasted in heat at the spark gap. This Oscillator is designed for the production of wave lengths of from 600 amperes to 950 amperes efficiency.

	a ¼	b ½	c 1 K. W.
Each	$16.50	16.50	38.00

95–430 ADJUSTABLE SPARK GAPS. No part of a sending set is more likely to cause loss of energy than a poorly constructed spark gap. In many instances efficiency is cut down one-half through loss at this point. In our instruments we use an especially prepared zinc electrode, capable of withstanding heavy currents **5.50**

RECEIVING APPARATUS IN SEPARATE UNITS

DETECTORS

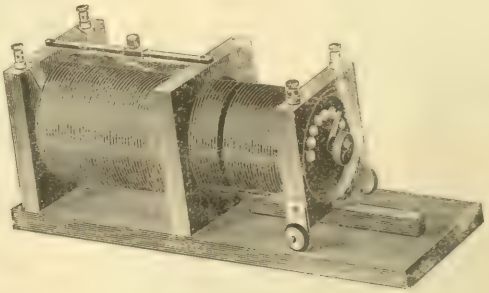


No. 95–435
Patented

No. 95–440
Patented

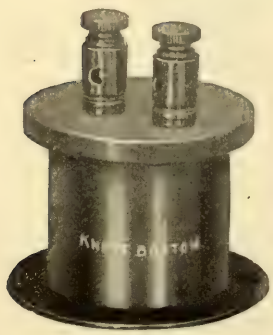
95–435 SILICON DETECTOR. This form of Detector is well known to all who are interested in wireless apparatus, and some of the longest records have been made with this type of instrument. It is fully guaranteed and furnished to us by a manufacturer especially licensed by the inventor . . . **$15.00**

95–440 IMPROVED FERRON DETECTOR. The new Ferron Detector is made up of a metallic crystal held in a nickeled cup, mounted on the usual form of detector stand. An exceedingly fine adjustment of pressure is easily obtained by means of a triple spring operated by a milled head rubber rod. Mounted on substantial marble base 5½ × 3 inches. This Detector is simple and operates best without either Potentiometer or battery **5.80**



No. 95–445

95–445 TUNING COIL of the **loose couple type.** This instrument has been especially designed for educational institutions where it is desirable, in order to show the construction of the essential working parts, to withdraw entirely the primary from the secondary coil. Special provision has been made for this so that it may be drawn fully from the secondary and inserted without danger of binding. The adjustment is easy and positive. The primary of the coil is of unusual capacity, enabling the shortest and longest wave lengths used by commercial stations to be received with a comparatively small antenna, and without the use of additional inductances or condensers. The secondary is made much larger than is usual and mounted on pivoted wheels **$15.00**



No. 95–455

95–450 HEAD BAND RECEIVERS. Double, 2000-ohm resistance . . . **12.00**

95–455 FIXED CONDENSER. The most approved methods of connecting a modern receiving station require a small condenser of fixed capacity in addition to the variable condenser used in tuning purposes. It is mounted in a nickel-plated brass cylinder fitted with hard rubber top carrying binding posts. Its capacity is approximately .003 M. F. **2.30**

VARIABLE AIR CONDENSERS. See page **484**.

ELECTROLYTIC RECTIFIERS

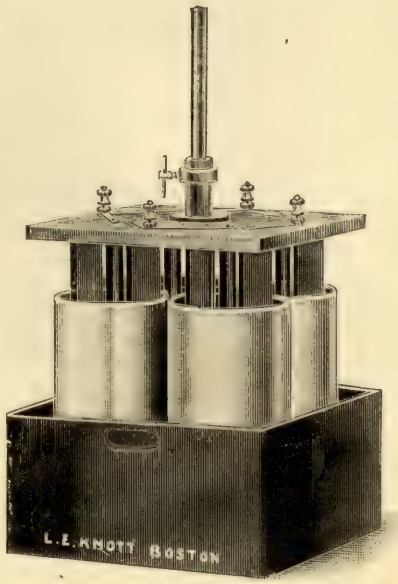
95–485 ELECTROLYTIC RECTIFIER, Nodon valve type, designed for use on 110-volt alternating current giving a direct current of the pulsating form, but one in which the negative part of the wave is entirely cut off, so that for most purposes this transformed current takes the place of a direct current of equal voltage. The charging of storage batteries, experiments in electrolysis, charging of electromagnets, complete series of experiments showing the mutual attraction and repulsion of currents, etc. may be performed with this current.

The valve here illustrated is of substantial construction, heavy porcelain jars, lead plates, aluminum rods of generous proportions, slate top and connectors, substantial iron rod support, and wooden carrying case.

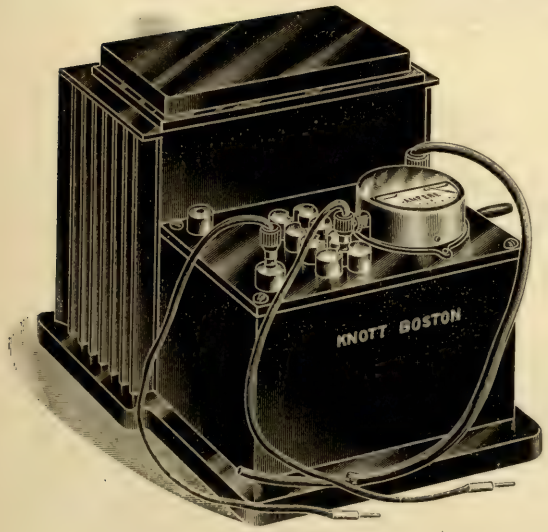
Full directions for connections and use furnished with each instrument.

Large amperage may be drawn from this instrument, but for brief periods only, owing to the fact that no adequate arrangements have been made for radiating the heat.

Complete **$14.75**



No. 95–485



No. 95–490
Patent Pending

95–490 THE NEW MULTIPLE RANGE SELF-COOLING RECTIFIER, with ammeter, designed for use on 110-volt alternating current and to deliver a **direct current** of **varying voltages.** As ordinarily furnished **3, 6, 9,** and **12 volts** have been provided for, being the ranges most generally useful in laboratory work. In addition to these a **12-volt alternating current** may also be drawn. As will be noted from the illustration, the instrument is provided with an ammeter so that the exact consumption on the direct current circuit may be noted constantly.

The terminals on the top of the case are connected to various sections of the transformer, each clearly marked so that the user can tell at a glance what voltage he is drawing.

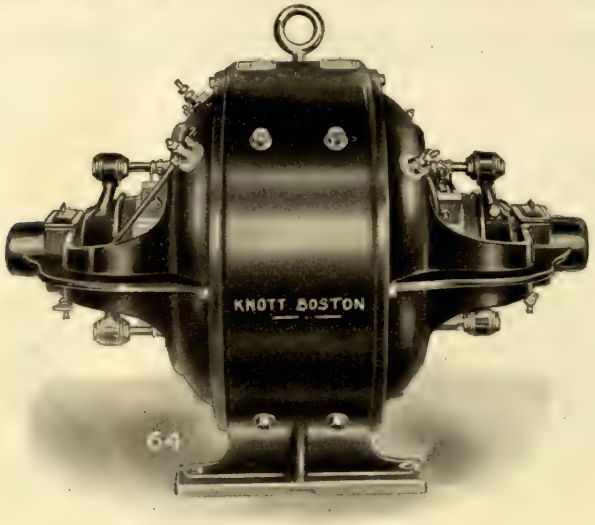
General construction. Owing to the care which has been taken to properly dissipate the heat, large amperage may be drawn from this instrument continuously. The metal case is made with radiating vanes, the case itself serving as one of the electrodes, so that the heat generated is taken care of by conduction and radiation as fast as produced.

This outfit will be found not only much more convenient to use than the electrolytic rectifiers of the type No. **95–485,** but is also much more efficient. The fact that multiple voltages can be drawn enables it to fill a need in laboratory work which has long been felt. These instruments should be provided in every laboratory where a direct current of low voltage is not already provided for.

Complete directions furnished with each instrument.

Complete with ammeter, mounted as shown in the illustration **$38.00**

ROTARY CONVERTERS



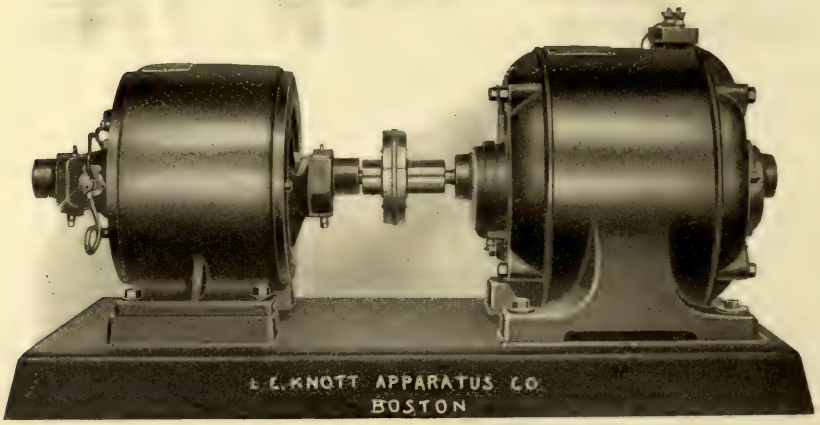
Nos. 95–500 to 95–506

Our Rotary Converters are of the same high quality as are our Generators and Motors listed in Section **97.** The conversion of the Direct to the Alternating current is accomplished with the highest efficiency output. They are guaranteed against mechanical and electrical imperfections.

Prices include Automatic No-voltage Release Starting Box.

	Output Watts	Speed	Price Volts Input 110	220
95–500	75	3600	**$50.00**	**$53.00**
95–502	100	3600	**52.50**	**55.50**
95–504	150	3600	**55.00**	**58.00**
95–506	250	1800	**60.00**	**64.00**

MOTOR GENERATORS



Nos. 95–510 to 95–520

These Motor Generators are intended for those schools which have an available Alternating Current and which desire a Direct Current. Our line listed below is of standard quality guaranteed against mechanical and electrical defects.

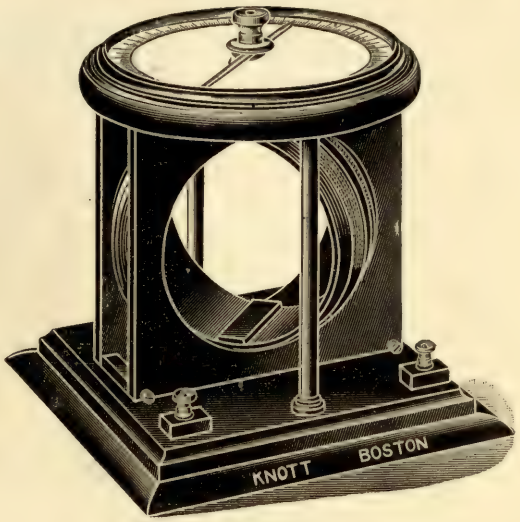
Prices include suitable rheostat when needed.

	A. C. Motor, 60 cycle, single phase, 1740 RPM, 110 or 220 volts H. P.	Generator Watts	Price
95–510	1/6	60	**$80.00**
95–512	1/4	120	**96.00**
95–515	1/2	175	**142.00**
95–517	1/2	250	**165.00**
95–520	1	500	**215.00**

INDUCTANCE AND CAPACITY APPARATUS

SELF-INDUCTION APPARATUS

Nos. 96–10 to 96–40



Nos. 96–50 to 96–52

STANDARD SELF-INDUCTION COILS. The knowledge of exact measurements in the matter of self-induction and capacity is of the greatest importance in setting up and in the use of machines, measuring instruments, and apparatus operated by alternating currents, as in installing of telegraph and telephone apparatus, cables, and circuits of all kinds. By the use of standard self-induction coils and simple measuring appliances it is possible to determine these values very exactly.

The self-induction coils above listed have been prepared in accordance with the principles laid down by the Reichsanstalt. They are spools of wire of known self-induction wound upon cylinders of serpentine, wholly free from iron and immovably fixed upon these cylinders.

These spools are so encased in a vulcanized rubber covering that they are protected against injury from the outside. By avoiding all metal parts except very small clamps, and by the divisions of the turns of the coil the presence of eddy currents is effectually avoided.

The standards are tested with great care to .002 of their stated value.

96–10	**STANDARD SELF-INDUCTION COIL,** capacity 1 Henry	Duty Free	**$36.75**
96–12	——, capacity 0.5 Henry	" "	**29.80**
96–14	——, capacity 0.1 Henry	" "	**21.25**
96–15	——, capacity 0.01 Henry	" "	**16.50**
96–17	——, capacity 0.001 Henry	" "	**13.50**
96–19	——, capacity 0.0001 Henry	" "	**11.00**
96–30	**STANDARD SELF-INDUCTION SPOOLS,** same as above, but wound on marble spools; capacity 1 Henry	Duty Free	**46.50**
96–32	——, capacity 0.5 Henry	" "	**36.75**
96–34	——, capacity 0.1 Henry	" "	**28.50**
96–36	——, capacity 0.01 Henry	" "	**21.00**
96–38	——, capacity 0.001 Henry	" "	**19.75**
96–40	——, capacity 0.0001 Henry	" "	**19.00**
96–50	**AYRTON and PERRY'S VARIABLE STANDARD OF SELF-INDUCTION,** reading directly to Millihenrys, range from 4 to 40 Millihenrys. Wood mounting	Duty Free	**130.00**
96–52	——, same as above, but constructed of ebonite	" "	**145.00**

Nos. 96–60 to 96–65

96–60 ADJUSTABLE INDUCTANCE. These inductances are made up of copper wire wound on a threaded hard rubber tube, — a construction that has been found to give excellent results both mechanically and electrically.

A smooth-acting slide permits any desired amount of the wire to be placed in circuit, and a scale on the slide support gives the value of the portion in use.

These inductances will be found well suited and convenient to use in connection with High Frequency currents and Wireless telegraph outfits.

Capacity 1000 Millihenrys **$26.00**

96–65 ——, same as above, capacity 5000 Millihenrys **58.00**

CONDENSERS

No. 96–117

Nos. 96–135 to 96–140

96–105 **CONDENSERS,** paper and tinfoil rolled type. These condensers have a guaranteed capacity, and the average insulation resistance of 100 megohms and not less than 50 megohms per micro-farad.

	a	b	c
Capacity	½	1	2 M. F.
Each	**$1.20**	**1.30**	**2.10**

96–110 **SUBDIVIDED PAPER CONDENSER,** ½ to 2 M. F. by ½ M. F. steps. Enclosed in polished wooden case **$6.75**

96–115 **SUBDIVIDED PAPER CONDENSER,** excellent grade, capacity one micro-farad, subdivided into four steps,—0.1, 0.2, 0.2 and 0.5 M. F. Enclosed in polished wood case as illustrated under No. **96–117** . . . . . Duty Free **32.40**

96–117 ——, same as above, but capacity 2 M. F. subdivided into five steps,—0.1, 0.2, 0.2, 0.5 and 1 M. F. Duty Free **40.00**

96–125 **MICA CONDENSERS.** These condensers are constructed by an improved process in which the mica leaves are silvered on both sides. This direct deposit of metal without any foreign substance permits of the full dielectric properties of the mica. It will be noted also that the deposit of silver adhering so closely to the mica forms a perfect condensing surface. It will be found by actual tests that the stated capacities remain constant.

	a	b	c	d
Capacity	0.1	0.2	0.5	1 M. F.
Each, Duty Free	**$22.40**	**30.00**	**38.50**	**59.00**

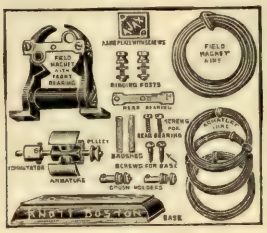
PAPER and **MICA CONDENSERS** of other capacities than above listed, also **SUBDIVIDED CONDENSERS** of various ranges, furnished on application.

96–135 **VARIABLE AIR CONDENSER.** This is a standard instrument constructed of the highest quality material and of first-class workmanship throughout. The vanes are of aluminum, and the moving system works perfectly without interference of the plates or other objectionable features commonly met with in instruments of cheaper construction. The top is of the best grade hard rubber, insuring high insulation and durability . A binding post is provided connecting to the case for grounding in experiments where the utmost accuracy is required. These condensers will be found of great usefulness in wireless telegraphy and in experiments with currents of high frequency. Capacity .001 M. F. **28.00**

96–140 ——, similar to above, but with a capacity of .005 M. F. **42.00**

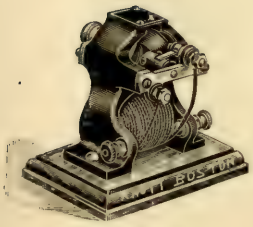
ELECTRO-DYNAMIC APPARATUS

DYNAMOS AND MOTORS

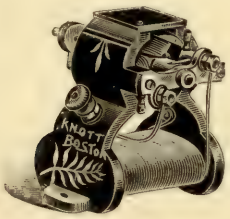


No. 97–10

97–10 MOTOR PARTS, complete parts for assembling a working motor. The popularity of the outfit above illustrated has demonstrated its efficiency as a pedagogic instrument. All parts ready to wind and assemble are enclosed with simple directions in a neat cardboard box. These parts and directions may be placed in the hands of any ingenious pupil who may readily assemble a motor for himself $1.10



No. 97–15



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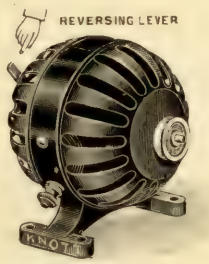
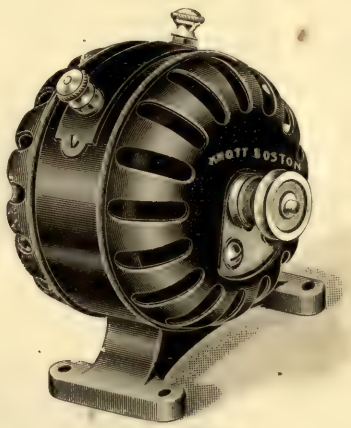


No. 97–30



No. 97–40

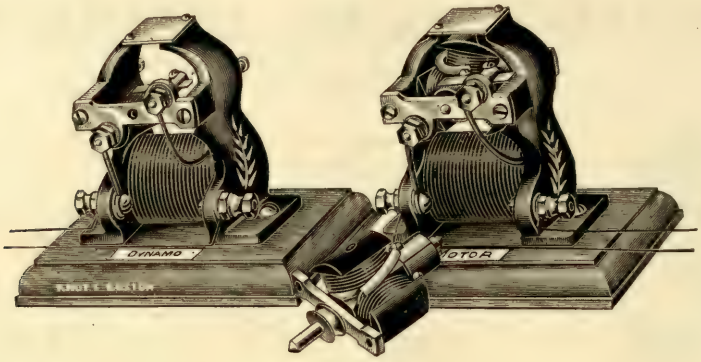
97–15 SIMPLE MOTOR. This motor though simple is well and substantially made. It is finished in black enamel with nickel-plated trimmings; mounted on polished wood base. It weighs about 1 pound and occupies a space 3 × 3¼ × 4 inches.
It will run efficiently on a single battery cell $1.50

97–17 SERIES WOUND DYNAMO, same simple and substantial structure as above. Effectively used with above in combining a simple Motor Generator . . . 2.00

97–25 STANDARD MOTOR. This motor is built for efficiency. It is designed to operate on two or three cells of battery. Will run about 2800 R. P. M. with average load on a current of 2 amperes at 4 volts.
Finished in black enamel with brass terminals. Weighs about 2¾ pounds; occupies a space about 4 inches square $3.25

97–30 REVERSING LEVER MOTOR. This motor is similar in design to No. **97–40** though built on a smaller plan. It is wound for battery current only and runs to full efficiency on two or three dry cells. Stands about 3¼ inches high and weighs about 15 ounces.
A feature of this motor is the reversing lever designed to start, stop, and reverse the motion of the armature 3.75

97–40 AIR-COOLED MOTOR. This small motor, standing 3⅜ inches high and weighing 20 ounces, is built on the lines of large machines. With the exception of the base no cast iron is used in its construction. The field is made of the best charcoal iron, annular field coil carefully taped and shellaced. The armature is laminated and slot wound. It is provided with self-lubricating bearing so constructed as to always be in perfect alignment, the cups having covers. The commutator segments are of hard copper carefully insulated with mica. Brushes are self-adjusting. Steel armature shaft fitted with grooved brass pulley ⅝ inch in diameter. This motor is handsomely finished throughout, the frame and base being finished in black enamel. It is highly recommended as a most powerful battery motor 4.50



No. 97–60

97–60 STUDENTS' MOTOR GENERATOR, for the study of the construction and operation of a simple dynamo and motor. This is a complete power station in the smallest practical size for students' laboratory work. The general design is such as all doubtless are already familiar with, but made of much higher quality of workmanship, and consequently more efficient.

The motor is wound for a 4-volt battery current, the dynamo is series wound, and proportioned to give the best possible results as a generator, notwithstanding its small size. The dissectible features of both dynamo and motor are important for both laboratory instruments. They will be found valuable educational instruments in studying the complete transformation of electrical energy from the battery through the motor, dynamo, and galvanometer.

Both instruments are mounted and clamped to a neatly polished wooden base and direct connected by a short belt. With the use of this combination a student is able to compare the parts of the dynamo with the corresponding parts of the motor, to observe points of similarity and points of difference.

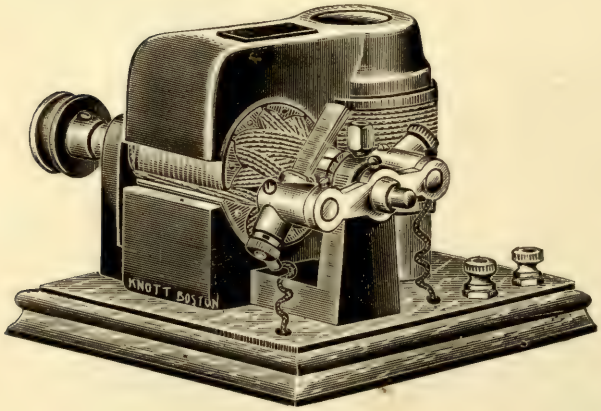
The instrument utilizes our popular Turner Base and Clamp which binds both motor and dynamo in correct alignment in a simple and efficient manner **$4.45**

97–62 TURNER & HERSEY BED CLAMP, for small power station. This base, as supplied in above apparatus, is designed for easy and effective coupling of a motor and dynamo. In students' experimental work it is necessary that the two units be held rigidly in position, but that sufficient adjustment be allowed for readily tightening the belt. The metal clamps provide an easy and effective method of regulating the distance and of tightening the belt.

Complete . . . . . **.95**

SIMPLE DYNAMO. See No. **97–17.**

SIMPLE MOTOR. See No. **97–15.**



No. 97–70

97–70 DYNAMO-MOTOR, field of soft gray iron, armature, — eight sections of the laminated tunnel drum pattern, shunt wound with silk enameled wire, commutator eight sections amply insulated with large carrying capacity, brushes of best pattern and quality, bearings of brass with large oil cups, finish bright enamel and nickel-plate, mounted on polished wood base 4¾ × 5½ inches.

As a Dynamo its output at full speed of 3000 to 3200 R. P. M. is about 30 watts (12 volts and 2.5 amperes). It will be found very useful for furnishing current for many experiments in the study of Electricity and Magnetism. It will charge a six-volt 40-ampere-hour storage battery in 12 hours.

As a Motor it operates on 6 to 12 volts of battery current, giving about 1800 R. P. M. at 8 volts and 2500 R. P. M. at 12 volts. It will develop about 1/25 H. P.

This Dynamo-Motor is furnished with a pulley 1½ inches in diameter, V-groove for a 5/16-inch round belt **$7.75**

No. 97–100

THE MOTOR DYNAMO DEMONSTRATION APPARATUS

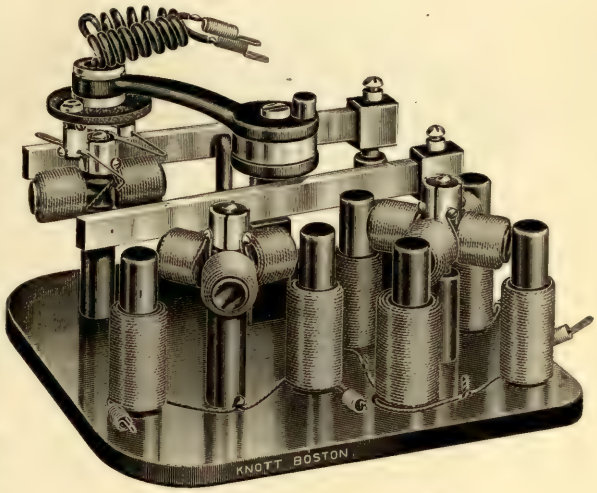
The apparatus shown in the illustration is an improved form of the apparatus formerly known as the "St. Louis Motor," and it is to overcome the defects of this instrument that the present form has been designed.

As will be noted in the illustration, any desired arrangement of field poles and armatures may be tested at will without the necessity of connecting or disconnecting coils or terminals.

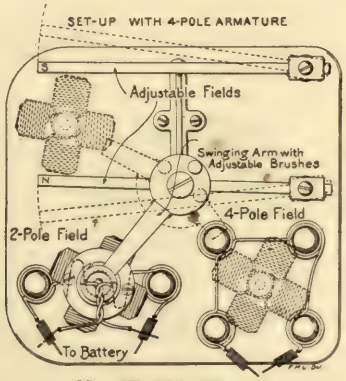
Motors having a permanent magnetic field or an electromagnetic field may be instantly compared, it being necessary to merely swing the brush holder over the armature that it is desired to make use of. The armature being held but by one vertical bearing, interchange of armatures may be instantly made; that is, a three-pole armature may be used in a four-pole field without the adjusting of a single screw.

A feature of this device which is of much practical importance is the place provided for all parts to be attached to the base of the instrument, hence reducing the liability of any part being lost or broken.

From an educational point of view, teachers will appreciate the **open construction** and the ease with which the student may see at a glance the various **poles** of **either type of dynamo or motor**, and in consequence be free from the perplexing problem of determining the exact position of the pole.



No. 97–100



No. 97–100 (Fig. 1)

2-POLE ARMATURE
Fig. 2

3-POLE ARMATURE
Fig. 3

4-POLE ARMATURE
Fig. 4

Some of the points that may be easily studied by the student are briefly outlined as follows:—

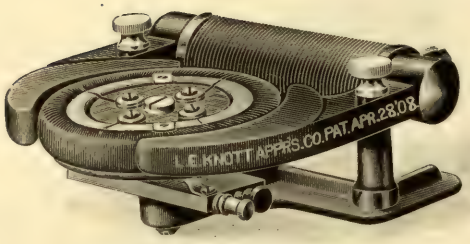
1. The two-pole Magneto.
2. The two, three, or four-pole Armature in a two-pole field.
3. The effect of varying the strength of the field.
4. Shunt-wound Motors having like or unlike number of armatures and field poles.
5. Series-wound Motors having like or unlike number of armatures and field poles. (This point is rendered especially easy since all the armatures are interchangeable with all the field systems so that they are easily combined in any desired manner.)
6. A study of the neutral point.
7. A study of the effect of changing the direction of the current in either armature or field.

Many other experiments applicable to the Dynamo and Motor may be readily performed.

Price complete with 3 Armatures,
6 Field Coils,
2 Bar Magnets **$3.85**

No. 97-115

GILLEY GRAMME MACHINE



No. 97–115 Fig. 1

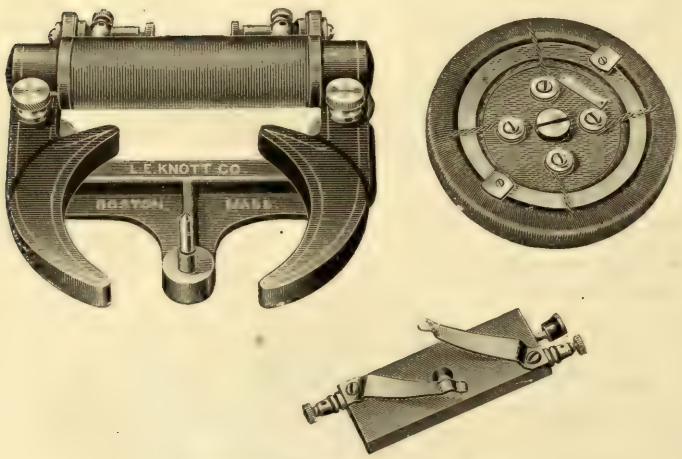
The Gramme Machine represents a type of generator now generally used in large units for power and lighting stations. The Gilley Gramme Machine is a modification so worked out that the lines of force may be easily plotted by the compass and filings method.

No other apparatus has yet been designed with which it is possible to show the lines of force in a working model of the dynamo and motor with the armature in position and in actual operation. Both the field and armature are designed and made in flat form, so that the upper surfaces of both are level, permitting the paper or glass upon which the lines of force by the filings method are to be mapped to take a smooth horizontal position. The lines of force are thus permitted to arrange themselves under no other influence than that of the magnetic force existing in the armature and field.

Dissectible Features. Fig. **2** shows the three basic parts of the apparatus,—the armature with the commutator, the field magnet with base, and the brush-holder. The instrument is readily dissected, as the illustration shows. Each part may be studied separately, as will be noted from the following list of experiments.

We desire to call attention also to the fact that the field coil is easily removed from its base and the base so designed that 6-inch permanent magnets may be substituted for the field coil, thus teaching the fundamental principle of the magneto.

WHAT THE INSTRUMENT IS DESIGNED TO TEACH



No. 97–115 (Dissected) Fig. 2

Experiment 1. **Study of the field magnet** in an electro-magnet, the lines of force being mapped out either by compass or filings method.

Experiment 2. **To show what effect the soft iron ring** of the armature has upon field magnets. The value of this exercise is greatly increased by using the filings method of mapping the field and comparing the field with results obtained above.

Experiment 3. A detailed **study of the armature,** showing that it is wound in sections and where the ends of each section are.

Experiment 4. A **detailed study of the commutator** by passing the current into the armature magnet through the brushes, showing by this method the exact position of each section when polarity is reversed.

Experiment 5. The method of **answering** definitely **why the armature of a motor rotates.** The action of the lines of force as indicated by the filings method will make this clear.

Experiment 6. A **study of the magneto generator,** its relation to the regular commercial dynamo, showing definitely why the current is generated when the armature is rotated between the poles of a magnet.

Experiment 7. A **study of the magneto and its relation to the dynamo,** also why the armature in a magneto machine rotates.

Experiment 8. A **study of the dynamo using electro-magnetic field and armature.** Determining the relation of the armature to the field coils and the speed of the armature to the strength of the magnetic field.

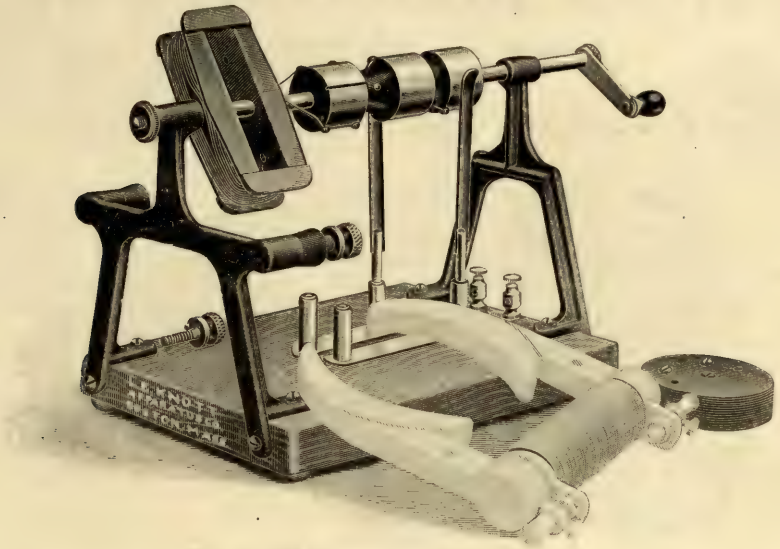
Experiment 9. The **study of different types of dynamos and motors** depending upon whether the armature and field are connected in series or in multiple, and what are the conditions regulating the method of connecting in any given machine.

Experiment 10. To show what the result will be if the armature is removed and a permanent bar magnet be mounted on the same bearing. This experiment teaches clearly the reason **why the armature must be an electro-magnet and not a permanent magnet.**

Gilley Gramme Machine **$7.75**

No. 97-125

MILLER-COWEN ATTACHMENT TO GILLEY GRAMME MACHINE

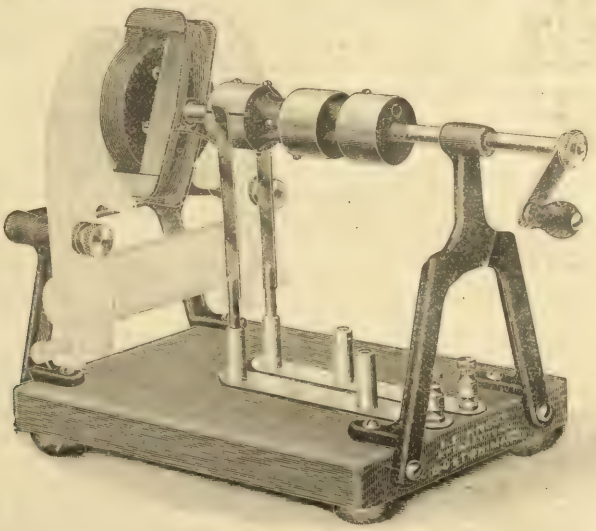


No. 97–125 (Dismounted Field Magnet)

This attachment, designed by G. A. Cowen and F. R. Miller of the Boston High Schools, further increases the educational value of the Gilley Gramme Machine by applying the method of clear open construction as used in that machine to the parts that are too often neglected but whose operation is of the utmost importance. This attachment allows of the removal of the armature iron so that experiments may be conducted either with a simple revolving armature coil or with the enclosed iron core as desired.

In addition to a large commutator, collecting rings are provided for the proper investigation of the alternating type of motor and generator. A handle furnishes a ready means of revolving the armature.

The use of this device in connection with our Universal Galvanometer No. **93–130** is recommended, as it is built to work in connection with an instrument of its range. This attachment is carefully constructed and most rigidly tested in our laboratory before shipment. Each instrument is guaranteed satisfactory, and its design will commend it as a valuable educational instrument.



No. 97–125 (Mounted Field Magnet)

Special Features. The large commutator for both A. C. and D. C., the ready means of changing brushes to make contacts with either A. C. or D. C. commutator without changing the galvanometer connections, the ease with which the field magnets may be removed and bar magnets substituted, the ready removal of the laminated core are features which make it an educational instrument of the utmost value.

As a dynamo analysis machine of simplest form it has met with much favor in vocational schools.

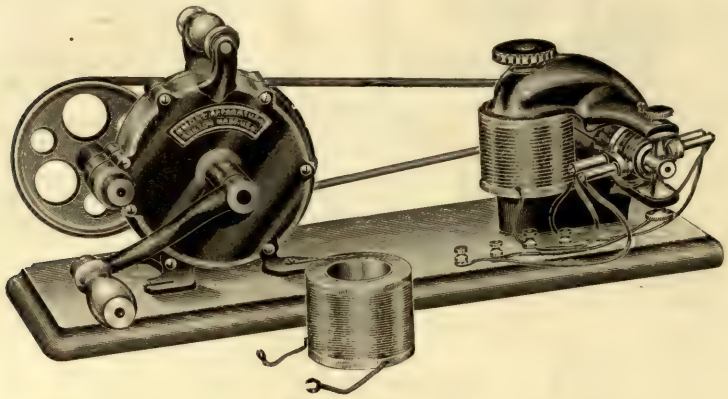
97–125 MILLER-COWEN ATTACHMENT, including the **Field Magnet** **$10.50**

97–127 MILLER-COWEN ATTACHMENT without the Field Magnet for those who already have No. **97–115** Gilley-Gramme Machine **8.00**

No. 97–150

DISSECTIBLE HAND POWER DYNAMO AND MOTOR

90 Watts Capacity A. C. and D. C. Low Voltage Generator



No. 97–150

97–150 DISSECTIBLE HAND POWER DYNAMO AND MOTOR. In the design of this apparatus we have made use of a practical commercial type of instrument assembled in such a manner that it can be most conveniently dissected for purposes of instruction. For this reason we have selected an open type field of the simplest possible design. No effort has been made to reduce the amount of iron in the field to a minimum.

Driving Mechanism for Hand Power. The hand power has been greatly improved, producing what is substantially a new type of hand power in educational work. Accurately cut gears operate under oil in an oil-packed casing. The casing is made of ample weight provided with a convenient handle at the top insuring stability and ease of control in operating the machine. This improved construction does away with the noise from exposed gears, insures proper lubrication, has the advantages of both belt drive and gear drive with the disadvantages of neither, and permits of ready disconnecting of the power from the generator when the generator is to be used as a motor.

Field Magnet. The field magnet is of the two-pole type which allows the use of a large amount of iron and permits of a construction which makes the shortest magnetic circuit, at the same time allowing a clear view of the pole pieces and their relation to the armature.

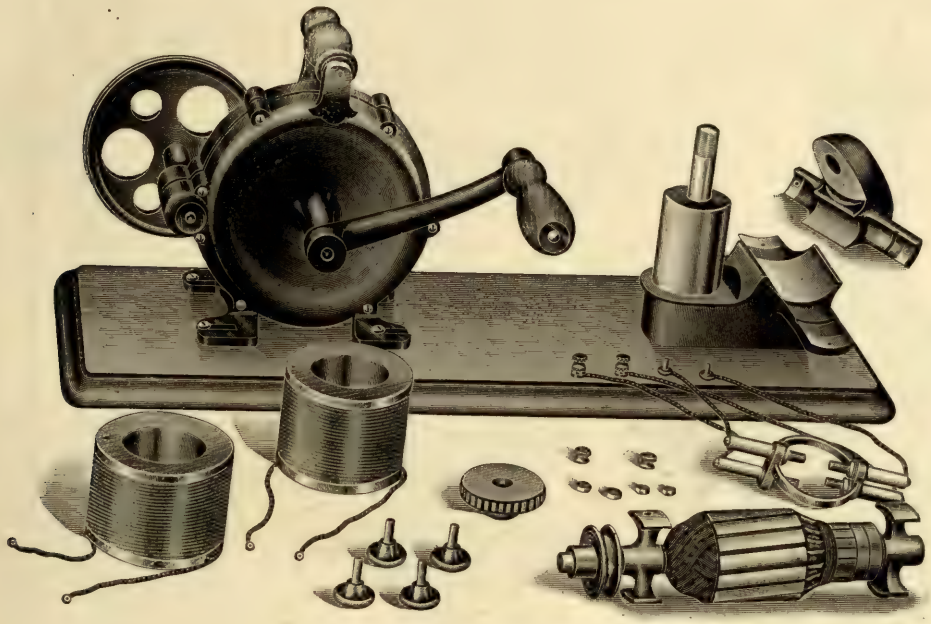
Field Coils. The field coils are wound on thin-spun metal bobbins, each core being designed for a definite purpose depending upon whether the instrument is to be connected series or shunt wound, giving the greatest efficiency for each type. Efficient results cannot be obtained with different methods of connecting unless especially designed field coils be used for each method.

Armature. The armature is of the drum type, which has proven best suited for withstanding hard usage. The coil sections are wound in slots in the **laminated iron core.** The anchoring of the coil has been done in the most perfect workmanlike manner.

Commutator. The commutator is of a somewhat larger size proportionately than would be used on a regular commercial machine, for the reason that it is a part of the design of this instrument that all of the essential features be large enough so that the students can readily study their functions.

Collecting Rings. These are placed on the same end of the shaft as the commutator, a design which somewhat simplifies the instrument. The attachment holding the brushes serves both for alternating and direct current circuit, thus offering a ready method of comparison.

Dissectibility. The entire instrument may be taken apart and assembled in the briefest possible time. Every part has been machined to perfect fit and for rapid assembling, thumb nuts being used instead of bolts and screws, — for instance, the two parts of the field magnet are bolted together by large milled thumb screws, allowing the field coils to be very quickly separated, exposing the armature, commutator rings, etc. for ready inspection. An important feature in this dissection is the fact that when the top half of the field magnet is removed the commutator may still be operated, showing clearly the exact relation of the armature, commutator rings, field coils, etc. We believe that this strong educational feature is obtained in no other instrument.



Showing Instrument Dissected

TYPES OF MACHINES

Direct Current Shunt Wound Dynamo. When the instrument is so used, the extra field coil not in use serves as a most convenient experimental coil for use with the generator.

Self-exciting Alternating Current Dynamo. The Dissectible Transformer, No. **95–30**, adds greatly to the educational value of this machine when it is used as an alternating current generator.

Series Dynamo. For series connection, the large wire field coil should be used and will give excellent results, although for general all-round work the series winding is not quite as efficient as the shunt winding.

Motor. This instrument serves admirably as a practical low voltage motor and may be used either series or shunt wound. For this work it will be desirable to disconnect the hand power. Anything that can be done with a ⅛-horse-power motor can be done with it. The fact that it may be used either as a shunt or series motor gives it a wide range in speed, even though not used in connection with a rheostat. We recommend, however, the use of a small rheostat for the complete regulation of speed.

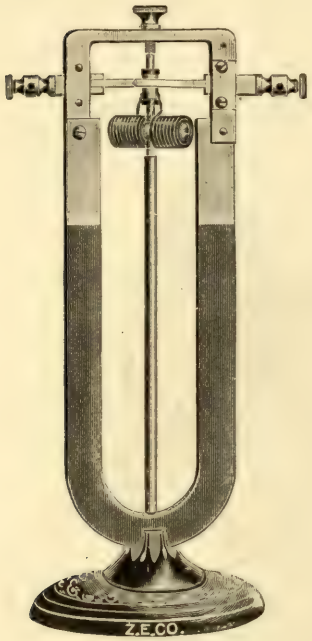
Rotary Converter or Motor Generator. When operated as a motor, by a suitable direct current, it will furnish an alternating current of sufficient intensity to perform many instructive experiments, and if used in connection with our Dissectible Transformer No. **95–30**, the alternating current may be transformed to 110 volts, strong enough to light a commercial 32-candle-power lamp.

Externally Excited Field Generator. The field coil may be connected to a battery or other convenient source of power and the dynamo used to deliver either direct or alternating current, thus demonstrating very clearly the large class of externally excited generators. This instrument is guaranteed when used as a dynamo to deliver 90 watts, but in practice the output will be found considerably above this amount. The following figures were recently obtained by actual tests on a stock machine:—

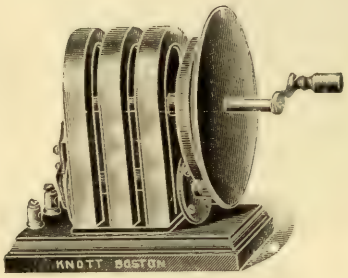
Amperes	5
Volts	20
Watts	100
Speed	2200 R. P. M.

When used as a motor, it delivered well above ⅛-horse power.

As the entire instrument is of the most substantial construction, it will run continuously without injury. It should not be classed as a school demonstration instrument only, as the entire construction is of such nature as to put it well within the class of commercial instruments **$40.00**



No. 97–160



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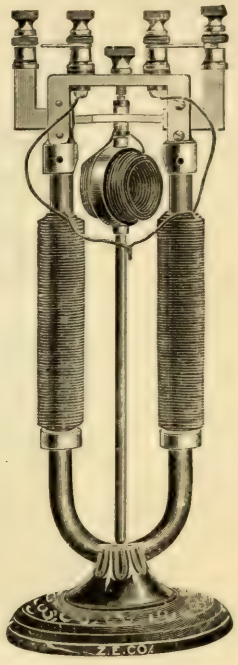


No. 97–165

97–155 MAGNETO. This instrument is a regular commercial dynamo of the permanent magnet type, employing magnets of unusual strength. A very efficient armature is provided with crank and gears so that it may be readily operated by hand. This instrument is frequently used in telephone exchanges and often as a testing instrument in locating broken circuits in coils. Its operation is similar to that which takes place in the Page Motor Apparatus below. Its educational value is in the practical and powerful effects that can be obtained by using permanent magnets. The earlier forms of power machines were built on this principle **$5.65**

97–160 PAGE MOTOR APPARATUS. This apparatus will be found of great value in teaching the basic principles of the electric motor and dynamo. By utilizing the horseshoe magnet, the student is not confounded with the unusual shape of pole pieces as met with in most motor or dynamo appliances. It will also be seen that the use of a permanent horseshoe magnet allows the armature and its commutator together with the brushes to be laid out on a flat surface so that each part can be seen whether as a unit or working together. If desired, the lines of force can be readily plotted in the usual method by iron filings. This instrument can be used either as a generator or a motor, as desired. By slowly moving the armature by hand, a clear understanding can be had of its operation.

The instrument is well made, employing a powerful magnet, so that it can be depended upon to give satisfactory results in the hands of students **8.50**

97–165 PAGE MOTOR APPARATUS, ELECTROMAGNETIC FIELD. This apparatus is particularly designed to show in a clear and comprehensive manner the action of an electromagnet as used in the modern motors and dynamos. The field coils are mounted on a soft U-shaped frame corresponding in general appearance to the permanent magnet of the No. **97–160** Page Motor Apparatus above, thus permitting direct and clear comparisons of the magnetic fields. The armature provided with this outfit still further illustrates the action of the electric current, for the iron used in the motor apparatus above is entirely dispensed with, the rotation being brought about by the direct action of the electromagnet field on a solenoid. Commutators, binding posts and brushes for connecting in various series and shunt combinations, are placed so that they can be clearly inspected. The apparatus will operate as a motor on two cells of battery.

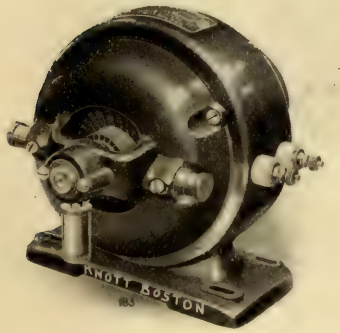
This apparatus is constructed accurately of the best obtainable material, and all parts are nicely fitted. It will be found a valuable instrument in the teaching of electro-dynamics. As a companion instrument with the Page Motor Apparatus No. **97–160,** a direct comparison of permanent and electromagnetic types of instruments makes an interesting study **9.75**

MOTORS

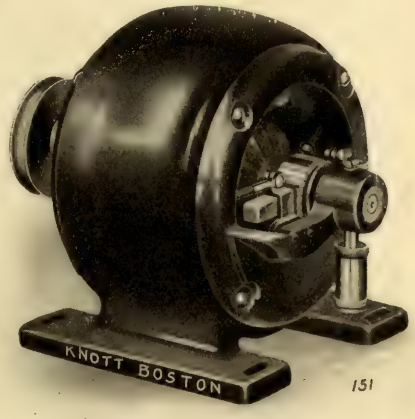
ALTERNATING AND DIRECT CURRENT

1/16 TO 1/4 H. P.

The well-known line of "Standard" Motors listed on this page is guaranteed to be mechanically and electrically perfect. The solidity of construction, the correctness of design coupled with the unsurpassed enameled finish, place them at once at the head of all motors. The material used is the best that can be obtained. They are of unusually high efficiency and are fully as durable as the larger size machines. They may be absolutely relied upon for years of satisfactory service.



Nos. 97–175 to 97–179



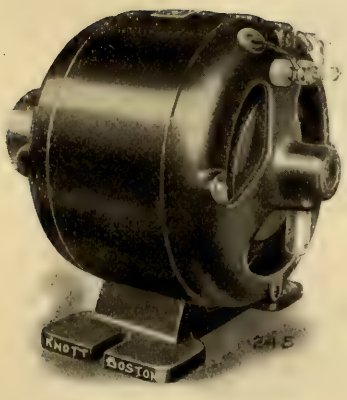
Nos. 97–181 to 97–183

DIRECT CURRENT COMPOUND WOUND MOTORS

Prices of series or shunt wound motors on application.

Number	H. P.	Speed	Prices Volts 110	220
97–175	1/16	1000	$12.80	$13.75
97–177	1/12	1500	14.25	15.50
97–179	1/8	2000	16.50	18.00
97–181	1/10	1200	18.25	19.75
97–183	1/8	1600	19.75	21.00
97–185	1/8	1200	26.00	27.75
97–187	1/6	1600	28.25	31.00
97–189	1/4	2000	32.00	34.50

SINGLE PHASE INDUCTION MOTORS

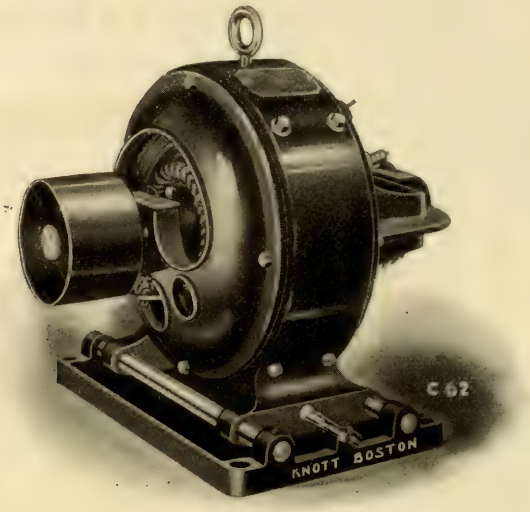


Nos. 97–200 to 97–222

Full Load Start		60 Cycles	Continuous Duty	
Number	H. P.	Speed	Prices Volts 110	220
97–200	1/30	1150	$17.50	$19.50
97–202	1/30	1750	16.00	18.00
97–204	1/20	1150	24.25	26.25
97–206	1/20	1750	21.00	23.00
97–208	1/10	1150	27.50	29.50
97–210	1/10	1750	23.75	25.75
97–212	1/8	1150	29.25	31.25
97–214	1/8	1750	28.75	30.75
97–216	1/6	1150	44.00	46.00
97–218	1/6	1750	40.00	42.00
97–220	1/4	1150	54.00	56.00
97–222	1/4	1750	51.00	53.00

GENERATORS

Nos. 97–270 to 97–272



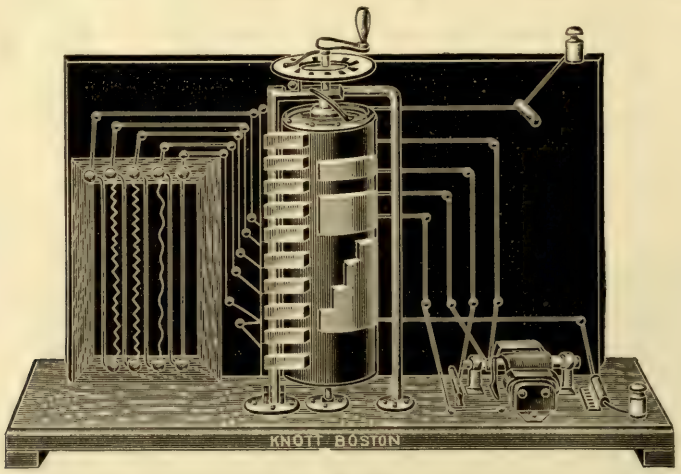
Nos. 97–274 to 97–278

The generators listed below are guaranteed to be of the very best material and workmanship, free from either electrical or mechanical defects, and will carry their rated load continuously without attaining a temperature greater than 40° Centigrade in excess of that of the surrounding air.

Prices are for compound wound generators and include standard pulley, sliding base with belt-tightening attachment and wall type field regulating rheostat.

The speed stamped on the name plate of each dynamo is that at which it should be driven when it is desired to operate it at the voltage marked.

Number	K. W.	Number of 55 Watt 16 C. P. Lamps	Speed 115 and 230 Volts	Size Pulley Diam.	Size Pulley Face	Price 115 V.	Price 230 V.
97–270	½	9	1850	4	2	**$48.00**	**$51.00**
97–272	¾	13	1750	4	2½	**62.50**	**65.00**
97–274	1	18	1650	5	2½	**80.00**	**84.00**
97–276	1½	27	1550	5	3	**88.50**	**93.00**
97–278	2	36	1400	5½	3½	**110.00**	**115.00**



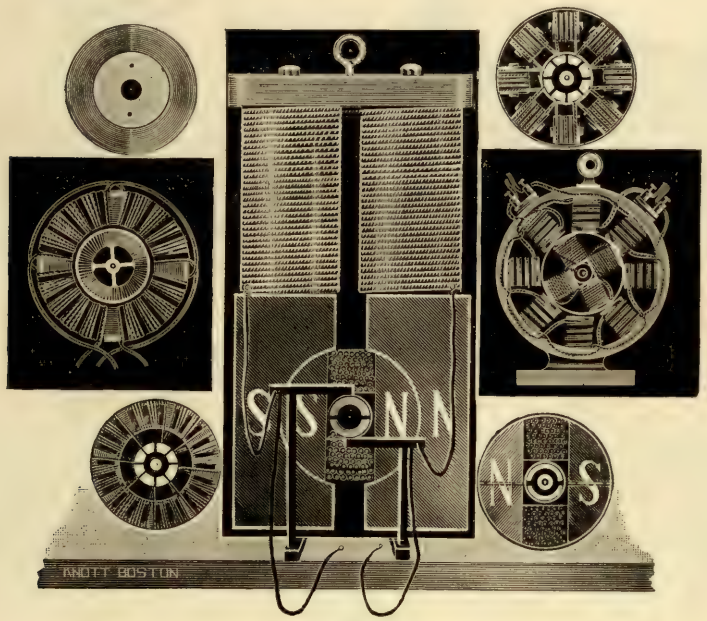
No. 97–285

97–285 CONTROLLER MODEL. The above illustrated device is designed to illustrate in a practical manner the method of controlling the speed and operation of the modern electric railroad motor. The commutator, resistances, etc. are well worked out in open construction so that the various changes that occur and their effects upon the included model motor may be noted with ease and accuracy.

The construction is substantial, parts clearly shown, and the whole design well suited for its didactic purpose.

Complete as illustrated with motor . . . . . Duty Free **$31.00**

ELECTRO-DYNAMIC CHARTS



No. 97–300

97–300 ELECTRO-DYNAMIC CHARTS, for demonstrating the principles of dynamos and motors. These charts, which are finely lithographed in colors and mounted on heavy cardboard, are of ample size, 28 × 30 inches. They may be seen across the largest lecture hall; the complex mechanism of the dynamo and motor, both alternating and direct current, may be clearly shown. The different windings, connections, armatures, poles, etc. are greatly magnified that they may be readily seen. Each chart is mounted in a frame, and the armature is rotated by means of a crank operated from the rear. That the change of polarity may be demonstrated, change of poles in the armature is automatically shown by different colors, one color for the North pole and another for the South pole.

The set consists of charts as follows: —

Group I. Double Chart consisting of: —

a. 1 Attachable hinged disc for the dynamo.
b. 1 Attachable hinged disc for the motor.
c. 2 Discs for Gramme's Ring.
d. 1 Colored disc for the magnetic field.
e. 1 Double Collector, one side with two collecting rings, the other with an eight-segment commutator.
f. 2 Brushes.
g. 4 Connecting Cords.

With the above Group the following demonstrations can be readily performed: —

1. Magneto Electric Machine, 2-pole armature, alternating current.
2. Magneto Electric Machine, 2-pole armature, direct current.
3. Two-pole Dynamo.
4. Dynamo with Gramme's Ring Armature.
5. Alternating Current Motor, 2 pole.
6. Motor with Gramme's Ring Armature.

Accessory Chart II. for use in demonstrating alternating current machines.
Accessory Chart III. for demonstrating alternating current motor.

Complete as above listed . . . . . Duty Free **$10.50**

ALTERNATING CURRENT DEMONSTRATION APPARATUS

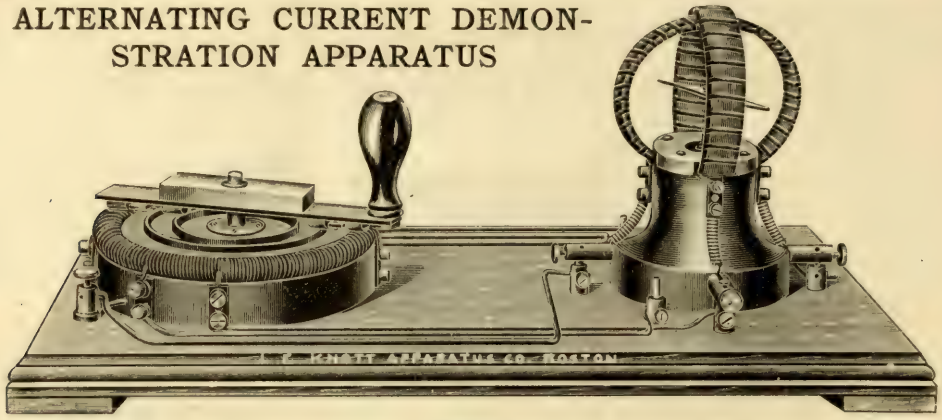


Fig. 1

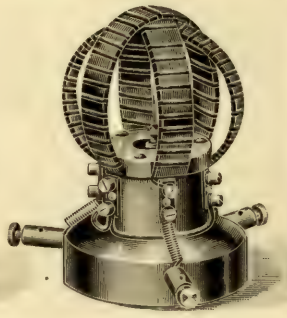


Fig. 2

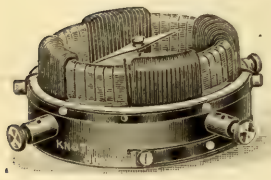


Fig. 4

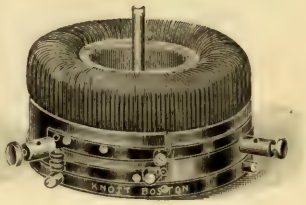


Fig. 5

Fig. 3
No. 97–310

97–310 WEINHOLD'S ROTARY FIELD APPARATUS, for the study of the essential principles of an induction or alternating current motor for either two-phase or three-phase currents, demonstrating clearly the rotating magnetic fields.

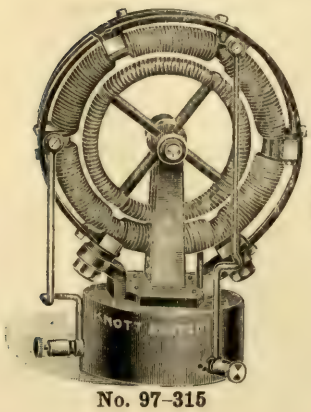
The complete apparatus consists of a substantial base on which are mounted the current distributing apparatus, Figure 1, connecting wires, and necessary devices for the interchangeable parts, the one illustrated on the base board being a double coil. In addition there are furnished accessory coils as follows: Ferraris' Double Coil, Figure 2; Ferraris' Triple Coil, Figure 3; 4-coil Iron Ring, Figure 4; Ring of 6 Coils, Figure 5; Magnetized Needle and Iron-plate Disc with agate socket; closed circuit armature; and perforated glass plate with alcoholized iron filings.

This apparatus permits of experiments demonstrating in a practical manner the effect of the rotary field. In use from 4 to 6 cells of battery are required. This current can be changed into an alternating current or rotary current by the distributing apparatus. This current is made to pass through the twofold or threefold crossed coils of wire of various colors. In the middle of either of these coils may be placed a magnetic needle or an iron disc. By the rotation of the distributing apparatus there is produced a current of either two or three phases, according as the twofold or threefold ring is used, and the bodies placed within the coils rotate under the influence of the rotary field. Instead of these wire armatures, however, an iron ring of 4 or 6 coils may also be used. Such rings, Figures 1 and 3, are wound with wire wrapped with a covering of different colors. By means of such rings synchronous rotation may be produced by the insertion of a magnetic needle or an iron disc; and by an iron ring wound with copper wire (closed circuit armature) non-synchronous rotation can be produced.

The lines marking the direction of the influence of the rotary field can also be more strikingly shown by means of a glass disc covered with the iron filings furnished with the apparatus.

This instrument is of substantial structure, all parts neatly and handsomely finished, especially designed for teaching the principles involved. The rotating parts are mounted with agate caps and steel-bearing points. All wiring is indicated by different colors. All connections are open to view on top of the base. The base is of highly polished hardwood.

Complete with full directions for use . . . . . Duty Free **$40.00**



No. 97–315

97–315 THREE-PHASE CURRENT MOTOR MODEL (Tesla Motor) for use with above Weinhold's Rotary Demonstration Apparatus, for the study of a rotary current motor.

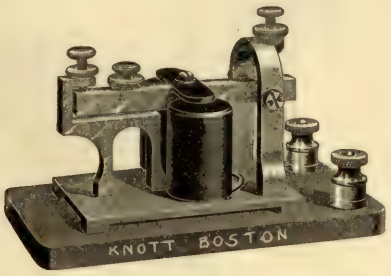
This model is furnished with six fields, closed circuit armature, with three leads. The winding is made in three colors and the connections are open and in colors. The apparatus is practical, clearly arranged, and shows the experiments in all their bearings.

It is highly recommended as an additional accessory to the above outfit . . . . . Duty Free **19.50**

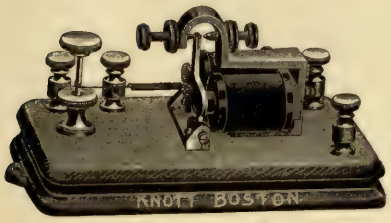
TELEGRAPHY AND TELEPHONY

TELEGRAPH INSTRUMENTS

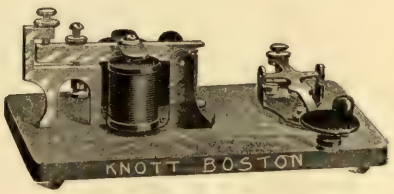
No. 98–10



No. 98–15



No. 98–20



No. 98–25

98–10 **TELEGRAPH KEY,** nickel-plated lever, brass frame, gutta-percha knobs, improved adjustment spring holders, all parts finely finished, without legs **$1.90**

98–15 **IMPROVED SOUNDER,** unequaled for quick action, loudness, and clear tone, proportioned scientifically correct, brass lever, resistance 5 ohms **2.50**

98–20 **TELEGRAPH RELAY,** excellent quality, finely finished and mounted on polished mahogany base with ornamented metallic sub-base. Standard resistance of 5 ohms **3.40**

98–25 **COMBINATION KEY AND SOUNDER.** This instrument is designed to fulfill the requirements of a short-line apparatus. The sounder magnets, lever, anvil, and key lever are the same as used on the preceding instruments. The frames for holding the sounder lever and key lever are stamped from wrought iron and heavily japanned. The base is constructed of polished mahogany.
This instrument will give entire satisfaction on lines up to five miles in length. Resistance 5 ohms . . . **2.50**

TELEPHONE INSTRUMENTS

No. 98–100

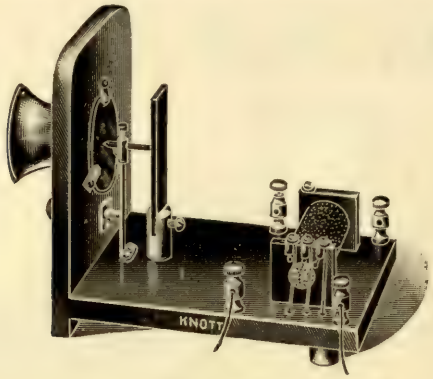
No. 98–105

No. 98–110

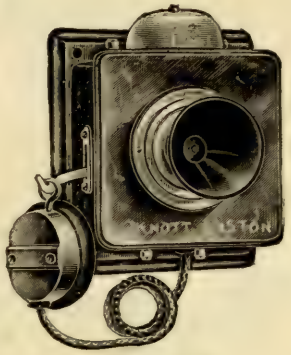
98–100 **DEMONSTRATION POSTLESS BI-POLAR RECEIVER.** As may be noted from the illustration, this instrument is entirely dissectible, and in consequence has a value as a demonstration instrument, as well as that of a working receiver. All parts are carefully fitted and finished and the receiver is high grade in every respect **$1.45**

98–105 **SOLID BACK WATCH CASE RECEIVER,** 2¼ inches diameter, weight 6 ounces, resistance 75 ohms, rigid adjustment.
This is a simple receiver sufficiently sensitive for practically all laboratory work **1.00**

98–110 **SOLID BACK LONG-DISTANCE TRANSMITTER.** This transmitter is the standard commercial type furnished on long-distance telephones. They articulate distinctly and plainly with no up and down variations or sizzling **2.00**



No. 98–125

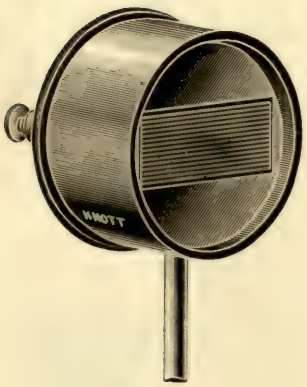


No. 98–135

98–125 TELEPHONIC MICROPHONE. This instrument illustrates in a clear and comprehensive manner not only the microphone but the adaptation of same in the articulating telephone. It is in reality two instruments in one, requiring only the simple adjustment of a thumb screw to change it from a simple contact telephone to a practical working telephone. The small induction coil on the base shows the manner of raising the potential of the telephonic circuit, which is inductively connected. The results attending the connecting of the instrument with an ordinary telephone receiver and battery cell are surprising. The ticking of a watch or the fall of a feather is heard with remarkable distinctness **$5.75**

98–135 KNOTT BATTERY CALL TELEPHONE. This is a handsome well-constructed instrument with solid back transmitter, double pole receiver, vibrating bell and call button. Guaranteed to give full satisfaction on all short lines. Readily set up from full directions which accompany the instrument . . . . . Each **4.25**
Per Pair **8.50**

SELENIUM CELLS



No. 98–142

Nos. 98–142 and 98–145

98–140 SELENIUM CELL. The scientific importance of the Selenium Cell has been recognized since the work of Bell and Ruhmer. It was not, however, until recently that its possibilities in the commercial field were fully realized. Many experimenters now agree that it is through the medium of the Selenium Cell that the "seeing" telephone may eventually become a reality.

In our work with Selenium we have discovered a most satisfactory method of attaching the material to the metal backing and improved methods of annealing are employed. The object has been to obtain a permanent surface and large area for the light to act upon and an area which will give as low initial electrical resistance as possible.

This Selenium Cell is extremely sensitive to light, dropping in resistance many thousands of ohms when illuminated by a light of average intensity. Connected in series with a relay and battery, it will cause the relay circuit to be closed when the cell is illuminated. If a screen be interposed between the light and the cell, the relay circuit will be immediately opened. A telephone receiver connected in series with the Selenium Cell and a suitable battery will cause fluctuations in light to be detected. For example, the alternating current arc gives a tone depending upon the frequency of the current. Changes in the intensity of a direct current arc produced by superimposing on it a telephone current are audible.

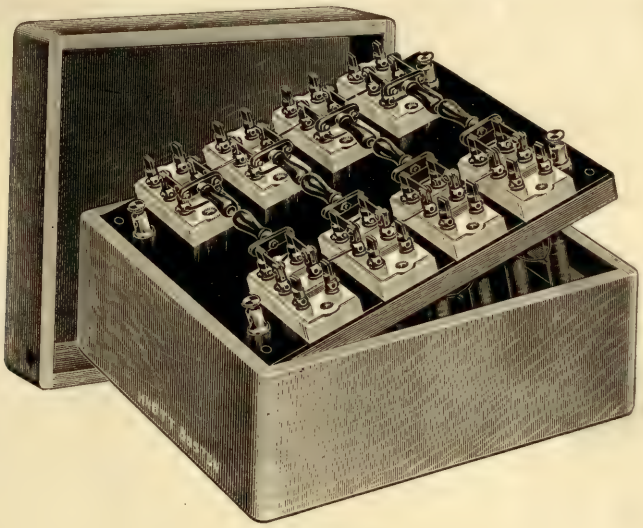
Selenium Cell unmounted, surface 7 mm. square **$5.00**

98–141 MOUNTED SELENIUM CELL, same as above, but with ring surface, inside diameter 12 mm.; outside diameter 29 mm. **8.50**

98–142 ——, same as illustrated above, with rectangular selenium surface. 45 mm. × 17 mm. **14.00**

98–145 UNIVERSALLY ADJUSTABLE SUPPORT, especially designed for holding the mounted Selenium Cell **2.50**

ARTIFICIAL TELEPHONE LINES



No. 98–150

Our Artificial Telephone Lines have been developed to meet the needs of the best and latest in telephone practice.

No scientific work in Practical Telephony can be done without a reliable **standard line.** The instruments which we offer will be appreciated by all laboratories giving courses in Telephone Engineering. They are offered in two standard sizes. Other sizes will be furnished on special order if desired.

CONSTRUCTION. Each line is made up of a series of unit resistances, each unit being equal to the resistance of one mile of cable. Connected at proper intervals are condensers, each having a capacity equal to one mile of the wire conductor. Suitable switches are employed so that any desired length of line can be thrown into circuit in units of one or more miles.

Each coil of the unit is inductively wound on especially prepared spools and protected from moisture by a coating of insulating material. The condensers are held in place in such a manner that their capacity will remain practically constant.

The capacity or mileage of the line is based on the full No. 19 gauge under-ground cable, this being used by a majority of the telephone companies as standard.

OVER-HEAD RATING. When desiring to represent over-head lines, its rated capacity should be multiplied by forty to meet average working conditions. (A mile of No. 19 gauge under-ground wire offers the same impedence as forty miles of the average over-head wire.)

98–150 ARTIFICIAL TELEPHONE LINE, capacity 10 miles equal to 400 miles of over-head wire **$60.00**

98–160 ——, same as above, capacity 50 miles equal to 2000 miles over-head wire **120.00**

ARTIFICIAL LINES FOR SUBMARINE CABLE

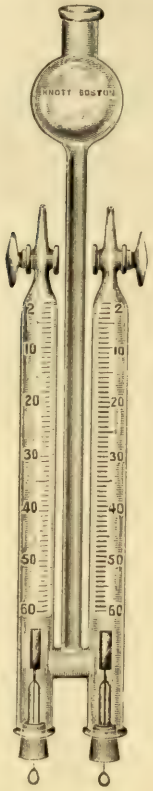
There is a growing demand for suitable Artificial Lines in connection with Submarine Telephony. Lines of varying capacity have already been worked out in our laboratory, but the capacity required to meet the average conditions has not yet been fully determined. We shall be pleased to quote on Submarine Lines arranged to meet any given conditions.

MISCELLANEOUS APPLICATIONS OF ELECTRICITY

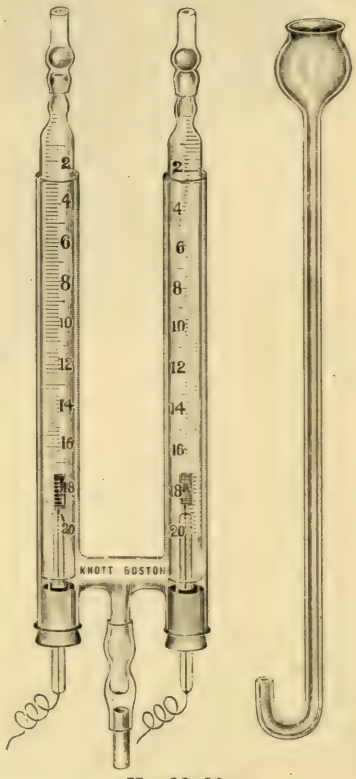
ELECTROLYSIS AND ELECTRO-CHEMISTRY

No. 99–10

No. 99–15



No. 99–20



No. 99–30

99–10 **SIMPLE ELECTROLYSIS APPARATUS.** This is the standard form with sliding graduated tubes and platinum electrodes **$2.50**

99–15 **THE H-ELECTROLYSIS OF WATER APPARATUS.** This is an improved type of electrolysis apparatus so designed that the platinum electrodes may easily be replaced by those of carbon or copper. In addition the reservoir tube is directly connected without bend to the junction tube of the gas tubes. This type is ungraduated, and is for use with rubber tubing and pinch-cocks.
Complete with platinum electrodes **2.60**

99–20 **THE HOFFMAN'S H-FORM ELECTROLYSIS OF WATER APPARATUS.** This design has the same improvements as the one above. It, however, has graduated gas tubes provided with glass stop-cocks and the reservoir is globular shaped.
Complete with platinum electrodes **7.50**

99–30 **OSBORNE'S IMPROVED ELECTROLYSIS APPARATUS.** This design has the merit of efficient use in study of principles involved in electrolytic dissociations. It consists of an H-tube with graduated slide tubes, each with shot valve. By the improved construction of detachable electrodes the platinum electrodes may be readily replaced by those of carbon or copper as illustrated. With a glass stopper plug the apparatus is set up as a conductivity cell. In use for study of electrolysis of water the stopper plug is replaced by the bent end of the thistle tube.
Complete as illustrated **4.80**

99–50 **CARBON ELECTRODES,** as used in Nos. **99–15** and **99–30** . . . . . **.55**

99–52 ——, for No. **99–20** . . . . . **.75**

99–55 **COPPER ELECTRODES.** as used in Nos. **99–15** and **99–30** . . . . . **.55**

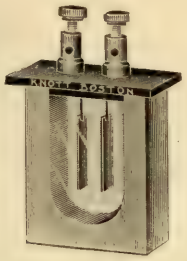
99–57 ——, for No. **99–20** . . . . . **.75**

99–60 **PLATINUM ELECTRODES,** as used in Nos. **99–15** and **99–30** **1.50**

99–62 ——, for No. **99–20** **3.00**

99–75 **TUBE SUPPORT.** It is always advisable and oftentimes necessary to support an Electrolysis of Water Apparatus during experimentation. Our support consists of a neat stand with clamp and binding posts **1.65**

99–80 ——, same as above, but smaller in size **1.40**



No. 99–100

99–100 LANTERN ELECTROLYSIS DEMONSTRATION APPARATUS. This design consists of a U-shaped trough provided with a hard rubber cover with binding posts to which are connected the platinum electrodes. This form will not leak and is not constructed with cumbersome compressor clamps.

It is a neatly and handsomely finished scientific piece of apparatus **$4.75**

MATERIAL FOR ELECTRO-PLATING

99–110 **Silver anode,** sheet form **$1.25**

99–115 **Nickel anode**, sheet form . . . . . **.75**

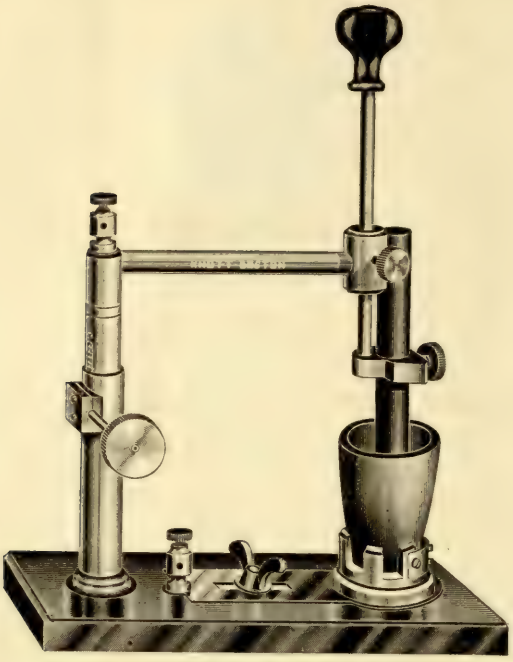
99–120 **Copper anode,** sheet form . . . . . **.50**
Copper sulphate, 1 lb. bottle . . . . . **.20**
Ammonia hydroxide, 1 lb. bottle . . . . . **.30**
Ammonia hydroxide, 4 lb. bottle **1.00**
Potassium cyanide, 1 lb. bottle . . . . . **.50**
Nickel and **Ammonium sulphate,** 1 lb. bottle . . . . . **.50**
Silver chloride, 1 oz. bottle . . . . . **.90**
Powdered pumice, 1 lb. package . . . . . **.15**
Rouge, 1 lb. package . . . . . **.40**
Tripoli, 1 lb. package . . . . . **.15**
Powdered emery, 1 lb. package . . . . . **.15**

99–125 **Rouge cloth,** specially prepared . . . . . **.20**

99–130 **Chamois Skin** . . . . . **.65**

We shall be very glad to supply the formulae on request for making solutions for silver, nickel, or copper electroplating.

ELECTRIC FURNACES

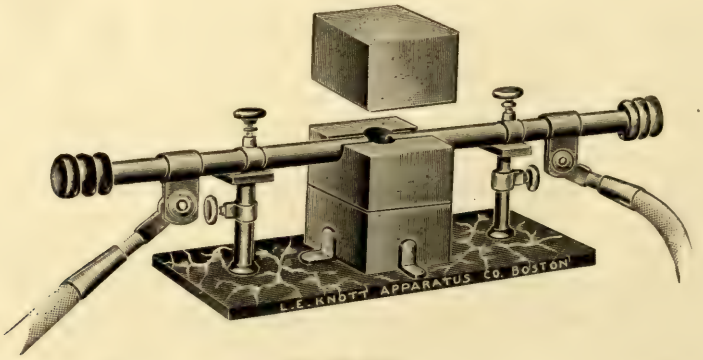


No. 99–200

99–200 SIMPLE ELECTRIC FURNACE. A simple practical form of electric furnace that will be found of great utility in the teaching of the electric arc, electric furnace, as well as the melting and combining properties of many elements. The construction enables a clear understanding of the many principles involved. Its open construction has much pedagogic value.

A great variety of experiments may be conveniently performed, — the melting of platinum or like refractory metals, the reduction or production of aluminum or carbides. The manufacture of calcium carbide from lime and sawdust or carbon makes a striking and interesting experiment.

Complete ready for use . . . . . Duty Free **$26.00**



No. 99–210

99–210 ELECTRIC ARC FURNACE, experimental type for currents up to 100 amperes at 50 to 60 volts. This furnace is designed to secure high efficiency. The crucible (50 × 45 millimeters) is contained in a large block of refractory, heat-insulating material, and has a heavy substantial cover that prevents loss of heat from the top. The carbon rods are arranged horizontally and can be readily renewed or adjusted. This outfit is capable of a wide range of advanced work.

Complete as illustrated without cables . . . . . Duty Free **$58.00**

ACCESSORIES

99–212 PAIR OF CABLES, 150 centimeters long, with connectors . . . . . Duty Free **$11.00**
99–213 CARBON CRUCIBLE . . . . . Duty Free **.75**
99–215 CARBONS, 500 by 22 millimeters . . . . . Duty Free Per Pair **1.00**

PHYSICAL APPARATUS IN GROUPS FOR CLASS DEMONSTRATIONS

In the various groups of Physical apparatus listed in this section, class demonstration work has been presupposed for the reason that in students' individual laboratory practice the selection of working material must of necessity be based upon the manual or laboratory guide which is in the students' hands. On the other hand, the apparatus which is to be used by the instructor in class demonstration should be the best piece of apparatus obtainable for teaching the fundamental principle.

We are glad at all times to make up lists of apparatus based upon the particular manual in use and upon the number of students in the laboratory division. We believe we have special facilities for doing this in the most comprehensive and satisfactory manner, making proper differentiation, not only in the design of the apparatus best suited to meet the particular manual, but also in adjusting the number of pieces best suited to the number in the laboratory.

For class demonstration, the lists we here present will be found of great service. Our reason for assuming that the suggestions which we offer are of value is based upon an unavoidable condition, viz. — that while the teacher has complete and definite knowledge concerning the educational side of the work, he has had little opportunity of becoming acquainted with the peculiar educational value of each instrument offered in such a complete list of Physical instruments as are shown in this catalogue. On the other hand, the manufacturer knows every detail of the instruments offered, but does not under usual conditions know the educational side of the question; neither can he be expected to make wise selection of the instruments best suited to the needs of the school of given grade. In order, therefore, to cover this gap most satisfactorily, we have enlisted the services of men of long experience in teaching and who have had ample opportunity of obtaining the most detailed information concerning each and every instrument offered in this catalogue. Through their aid we are able to offer these lists made out from a pedagogical point of view, but with fullest knowledge of the instruments from which this selection is made.

It will therefore be seen that these lists are not, as so often has been the case, taken as a medium for unloading out-of-date designs which the manufacturer proposes to replace in another edition. Every instrument listed will be found to be of the latest design and selected to meet the particular work in hand. We confidently expect, therefore, that these lists will be found of great value to every teacher.

To cover the needs of the individual school, bearing in mind the emphasis which the particular school desires to place on science instruction, we offer lists covering a considerable range.

Under this general heading will be found lists of material selected with special reference to covering the general outline of the subject, but not attempting to make possible adequate class-room demonstration for every principle discussed in the average high school text. With financial limitations a complete demonstration of every point is evidently impossible. The apparatus has therefore been selected with reference to teaching definitely the more important and salient topics of the subject, and the extent to which the subdivisions of each topic have been developed has been determined largely by the necessity of limiting the expense.

PHYSICAL APPARATUS GROUP "A"

LABORATORY HARDWARE

5-250	Eccentric-Leveling Base	$2.35		
5-40a	Support Rod, 19 mm. × 100 cm.	.90		
5-151	Support Rod, 13 mm. × 80 cm.	.55		
5-15b	Support Rod, 13 mm. × 40 cm.	.35		
5-770	Right Angle Clamps (2)	1.90		
5-1000	Basic Clamp "A"	1.15		
		——	$7.20	
			——	$7.20

MEASUREMENTS

10-30	Liter Block	$0.90		
10-40	Liter Case	1.10		
10-75	Vernier Caliper Model	2.75		
10-105	Copper Liquid Measures	2.25		
11-11	Meter Stick	.35		
11-145	Bristol Board Comparing Scale	.20		
13-105	Bristol Board Protractor	.12		
14-95	Wood Pocket Level	.40		
15-160	Trip Scale	5.75		
16-450	Interhooking Weights	2.50		
		——	$16.32	
			——	$23.52

MECHANICS

20-10	Porosity Demonstration Apparatus	$1.70		
20-95	Cohesion Discs, Glass	.65		
20-110	Prince Rupert Drops (1 dozen)	.25		
20-134	Capillary Tubes on Support	.44		
20-215	Osmosis Apparatus	1.25		
21-10	Mechanical Rotator	6.75		
21-60	Double Centrifugal Hoop	2.20		
21-175	Glass Rotator Globe	2.85		
21-210	Color Discs	2.00		
21-242	Savart's Toothed Wheel	.58		
22-222	Flexible Hardwood Strip	.45		
15-310	Spring Balances (3)	1.35		
24-25	Composition of Force Attachment	1.15		
25-100	Packard's Falling Body Apparatus	6.25		
25-230a	Pendulum Clamp	.95		
27-30	Demonstration Lever	1.95		
27-140	Pulley Assortment	2.80		
27-185	Pulley Cord	.20		
5-645	Hook Collars (4)	.88		
27-325	Wheel and Axle	1.45		
27-435	Inclined Plane Car	1.55		
		——	$37.65	
			——	$51.17

HYDRAULICS

31-45	Specific Gravity Group	$1.65		
31-230	Demonstration Hydrometer	.25		
31-250b	Hydrometer Jar, 12 × 2 inches	.45		
32-185	Liquid Level Communicating Tubes	.70		
32-231	Cartesian Diver	.25		
34-20	Hydraulic Press	1.65		
35-30	Model of Lift Pump	1.60		
35-32	Model of Force Pump	1.95		
		——	$9.50	
			——	$69.67

PNEUMATICS

41-115	Boyle's Law Apparatus	$2.85		
41-150	Barometer Tube and Mercury Well	.80		
42-75	Hand Air Pump	4.00		
43-247	Water Hammer	.65		
		——	$8.30	
			——	$77.97

SOUND

51-55	Tuning Fork A	$0.16		
51-57	Tuning Fork C	.16		
51-295	Demonstration Organ Pipe	4.00		
53-115	National School Sonometer	4.50		
53-117	Sonometer Wires (set of three)	.35		
54-147	Sand	.25		
57-20	Double-Bass Bow	1.50		
		——	$10.92	
			——	$88.89

HEAT

60-120	Alcohol Stove	$0.25		
60-250	Antimony Rubber Tubing, $\frac{3}{16}$" (6 feet)	.48		
60-350	Gilley Steam Boiler	2.25		
62-140	Franklin's Palm Glass	.45		
63-25	Chemical Thermometer	.40		
64-35	Air Thermometer	.22		
65-10	Cowen's Linear Expansion Apparatus	3.00		
66-65	Calorimeter	.50		
69-55	Locomotive Chart	2.25		
		——	$9.80	
			——	$98.69

LIGHT

71-50	Student's Photometer	$3.50		
71-352	Lens Holders (2)	.44		
71-356	Screen Holder	.12		
71-358	Pin Holder	.10		
72-12	Plane Mirrors (2)	.40		
72-20	Concave and Convex Cylindrical Mirror	.50		
73-100	Student's Optical Disc	12.75		
74-75	Gilley Index of Refraction Water Board	.75		
74-112	Demonstration Lenses (set of six)	1.25		
	Odd Angle Prism	.30		
74-280	Equilateral Prism	.33		
74-305	Right Angle Prism	.40		
74-480	Polyprism	.22		
78-77	Iceland Spar	.55		
		——	$21.61	
			——	$120.30

MAGNETISM

80-10	Lode Stone	$0.40		
80-70	Pair Bar Magnets	.50		
80-24	Horseshoe Magnet	.18		
80-100	Steel Rods (set of 4)	10		

80–105	Soft Iron Bar	$0.20		
80–180	Iron Filings (1 lb.)	.20		
81–12	Magnetic Needle	.60		
81–77	Magnetic Compass	.25		
			$2.43	
				$122.73

STATIC ELECTRICITY

82–15	Friction Rod of Glass	$0.18		
82–30	Wax Friction Rod	.10		
82–60	Catskin	.75		
			$1.03	
				$123.76

ELECTRICITY

90–15	Copper Annunciator Wire, ½ lb.	$0.35		
91–42	Demonstration Student's Battery	1.70		
92–130	Gilley Induction Outfit	$2.00		
92–165	Electro-Magnet	1.35		
93–30	Trowbridge Galvanometer	4.25		
	Vertical Volt-Ammeter	3.50		
94–70	Resistance Coils	3.00		
94–150	School Resistance Box	3.75		
94–470	Wheatstone Demonstration Bridge	5.80		
97–10	Motor Parts	1.10		
97–60	Students' Motor Generator	3.50		
98–25	Key and Sounder	2.50		
98–100	Demonstration Receiver	1.45		
99–15	Electrolysis of Water Apparatus	2.60		
			$36.85	
	Total for Apparatus			$160.61
	Cases			1.75
	Total			$162.36

Net Price f. o. b. Boston **$148.00**

PHYSICAL APPARATUS GROUP "B"

LABORATORY HARDWARE

5–250	Eccentric-Leveling Bases (2)	$4.70		
5–40a	Support Rod, 19 mm. × 100 cm.	.90		
5–15d	Support Rod, 13 mm. × 80 cm.	.55		
5–15b	Support Rod, 13 mm. × 40 cm.	.35		
5–770	Right Angle Clamps (2)	1.90		
5–952	Pulleys Mounted on Rod (2)	1.80		
5–1000	Basic Clamps "A" (3)	3.45		
5–1150	Basic Clamp "B"	1.90		
			$15.55	
				$15.55

MEASUREMENTS

10–10	Metric Chart	$2.50		
10–20	Liter Block	3.00		
10–35	Liter Case	3.00		
10–75	Vernier Caliper Model	2.75		
10–105	Copper Liquid Measures	2.25		
11–11	Meter Stick	.35		
11–145	Bristol Board Comparing Scale	.20		
12–95	Micrometer Caliper	5.65		
12–155	Vernier Caliper	2.15		
12–277	American Standard Wire Gauge	2.20		
13–105	Bristol Board Protractor	.12		
14–95	Wood Pocket Level	.40		
15–165	Agate-Bearing Trip Scale	5.65		
15–180	Trip Scale Support	2.85		
16–302	Brass Weights in Box	1.80		
16–450	Interhooking Weights	2.50		
17–50	Seconds Pendulum	6.90		
18–50	Circle Area Demonstration Apparatus	2.10		
18–125	Crystal Models	4.75		
			$53.12	
				$68.67

MECHANICS

20–10	Porosity Demonstration Apparatus	$1.70		
20–95	Cohesion Discs, Glass	.65		
20–110	Prince Rupert Drops (1 dozen)	.25		
20–117	Adhesion Discs	.50		
20–134	Capillary Tubes on Support	.44		
20–215	Osmosis Apparatus	1.25		
21–10	Mechanical Rotator	$6.75		
21–60	Double Centrifugal Hoop	2.20		
21–175	Glass Rotator Globe	2.85		
21–210	Color Discs	2.00		
21–240	Savart's Toothed Wheel	2.95		
21–360	Simple Gyroscope	5.50		
22–190	Collision Ball Apparatus	3.85		
22–222	Flexible Hardwood Strip	.45		
15–310	Spring Balances (3)	1.35		
25–10 to 25–80	Center of Gravity Set	6.57		
25–100	Packard's Falling Body Apparatus	5.25		
5–900	Pendulum Clamp	1.45		
26–30	Spiral Spring	1.95		
27–30	Demonstration Lever	1.95		
27–141	Pulley Assortment	4.40		
27–185	Pulley Cord	.20		
5–645	Hook Collars (4)	.88		
27–325	Wheel and Axle	1.45		
5–1035	Swivel Post Attachment	.74		
27–390	Inclined Plane	1.60		
27–435	Inclined Plane Car	1.55		
			$61.68	
				$130.35

HYDRAULICS

31–45	Specific Gravity Group	$1.65		
31–175	Universal Hydrometer	1.25		
31–230	Demonstration Hydrometer	.25		
31–250b	Hydrometer Jar, 12 × 2 inches	.45		
32–60	Pressure Gauge	2.50		
32–115	Pascal's Vases	6.75		
32–185	Liquid Level Communicating Tubes	.70		
32–231	Cartesian Diver	.25		
34–20	Hydraulic Press	1.65		
35–30	Model of Lift Pump	1.60		
35–32	Model of Force Pump	1.95		
			$19.00	
				$149.35

PNEUMATICS

40–22	Baroscope Globe and Bell in Vacuo	5.40		
41–115	Boyle's Law Apparatus	2.85		

41–150	Barometer Tube and Mercury Well	$0.80		
42–75	Hand Air Pump	4.00		
43–120	Air Pump Plate	4.90		
43–25	Bell Glass	1.00		
43–247	Water Hammer	.65		
45–10	Fortin School Barometer	8.90		
			$28.50	
				$177.85

SOUND

51–55	Tuning Fork A	$0.16		
51–57	Tuning Fork C	.16		
51–295	Demonstration Organ Pipe	4.00		
53–115	National School Sonometer	4.50		
53–117	Sonometer Wires (Set of three)	.35		
54–15	Vibrograph	4.00		
54–147	Sand	.25		
57–20	Double-Bass Bow	1.50		
54–165	Manometric Flame Apparatus	6.35		
			$21.27	
				$199.12

HEAT

60–120	Alcohol Stove	$0.25		
60–250	Antimony Rubber Tubing, $\frac{3}{16}$", (6 feet)	.48		
60–350	Gilley Steam Boiler	2.25		
60–400	Water Trap	.35		
61–160	Convectional Current Apparatus	1.90		
61–178	Hexagonal Conductometer	1.60		
62–140	Franklin's Palm Glass	.45		
62–150	Wollaston Cryophorus	1.40		
63–25	Chemical Thermometer	.40		
64–35	Air Thermometer	.22		
65–10	Cowen's Linear Expansion Apparatus	3.00		
65–75	Compound Bar	.95		
66–65	Calorimeter	.50		
66–200	Tyndall's Specific Heat Apparatus	2.00		
69–55	Locomotive Chart	2.25		
			$18.00	
				$217.12

LIGHT

71–50	Student's Photometer	$3.50		
71–352	Lens Holders (2)	.44		
71–356	Screen Holder	.12		
71–358	Pin Holder	.10		
72–12	Plane Mirrors (2)	.40		
72–20	Concave and Convex Cylindrical Mirror	.50		
73–10	Optical Disc	16.50		
74–75	Gilley Index of Refraction Water Board	.75		
74–112	Demonstration Lenses	1.25		
	Odd Angle Prism	.30		
74–280	Equilateral Prism	.33		
74–305	Right Angle Prism	$0.40		
74–480	Polyprism	.22		
77–85	Spectrum Chart	1.50		
77–350	Newton's Rings	1.50		
78–77	Iceland Spar	.55		
			$28.36	
				$245.48

MAGNETISM

80–10	Lode Stone	$0.40		
80–70	Pair Bar Magnets	.50		
80–24	Horseshoe Magnet	.18		
80–100	Steel Rods (Set of 4)	.10		
80–105	Soft Iron Bar	.20		
80–180	Iron Filings (1 lb.)	.20		
80–195	Blue Print Paper (pkg.)	.22		
80–280	Magnetoscope	1.25		
81–12	Magnetic Needle	.60		
81–77	Magnetic Compass	.25		
			$3.90	
				$249.38

STATIC ELECTRICITY

82–15	Friction Rod of Glass	$0.18		
82–25	Vulcanite Friction Rod	.42		
82–30	Wax Friction Rod	.10		
82–60	Catskin	.75		
82–190	Wimshurst Machine	12.00		
83–135	Students' Electroscope	.66		
84–20	Proof-Plane	.30		
85–10	Demonstration Leyden Jar	3.25		
			$17.66	
				$267.04

ELECTRICITY

90–15	Copper Annunciator Wire, ½ lb.	$0.35		
91–42	Demonstration Student's Battery	1.70		
92–22	Oersted's Law Apparatus Frame	2.25		
92–130	Gilley Induction Outfit	2.00		
92–165	Electro-magnet	1.35		
93–30	Trowbridge Galvanometer	4.25		
93–200	D'Arsonval Galvanometer	3.90		
93–650	Volt-Ammeter	6.50		
94–70	Resistance Coils	3.00		
94–150	School Resistance Box	3.75		
94–470	Wheatstone Demonstration Bridge	5.80		
97–10	Motor Parts	1.10		
97–60	Students' Motor Generator	3.50		
98–25	Key and Sounder	2.50		
98–100	Demonstration Receiver	1.45		
99–15	Electrolysis of Water Apparatus	2.60		
			$46.00	
	Total for Apparatus			$313.04
	Cases			3.50
	Total			$316.54

Net Price f. o. b. Boston $287.50

PHYSICAL APPARATUS GROUP "C"

LABORATORY HARDWARE

5–990	Lecture List "A," Bases, Support Rods and Clamps	$36.00	
			$36.00

MEASUREMENTS

10–10	Metric Chart	$2.50	
10–20	Liter Block	3.00	
10–60	Wooden Cubes	3.30	
10–70	Vernier Model	1.60	
10–85	Meter Stick	1.50	
10–105	Liquid Measures	2.25	
11–10	Meter Stick	.30	
11–145	Comparing Scale	.20	
12–75	Micrometer Caliper	3.30	
12–180	Caliper Arms	2.85	
12–230	Micrometer Screw	2.90	
12–277	Wire Gauge	2.20	
13–175	Student's Slide Rule	.50	
14–110	Balance Level	1.00	
14–130	Plumb Bob	.12	
15–115	Specific Gravity Balance Duty Free	19.25	
16–302	Brass Weights, 1 cg.–100 g.	1.80	
16–370	Fractional Weights	.95	
17–50	Seconds Pendulum	6.90	
17–75	Compensating Pendulum	9.90	
17–300	Speed Indicator	1.00	
18–40	Triangle Demonstration Apparatus	1.90	
18–50	Circle Area Demonstration Apparatus	2.10	
19–75	Drawing Instruments	4.35	
			$75.67
			$111.67

MECHANICS

20–10	Porosity Apparatus	$1.70	
20–95	Glass Disc	.65	
20–100	Film Demonstration Apparatus	.90	
20–110	Prince Rupert Drops (1 dozen)	.25	
20–117	Adhesion Disc	.50	
20–130	Tapering Capillary Tubes	.35	
20–140	Capillary Tube and Stand	1.15	
20–215	Osmosis Apparatus	1.25	
20–260	Impenetrability Apparatus	1.25	
21–10	Rotator	6.75	
21–60	Centrifugal Hoop	2.20	
21–175	Globe	2.85	
21–210	Color Discs	2.00	
21–260	Siren Disc	1.90	
21–280b	Disc only	.55	
21–290	Cubical Mirror	3.15	
21–360	Simple Gyroscope	5.50	
22–145	Impact and Reflection Attachment	6.65	
22–190	Collision Ball Apparatus	3.85	
22–225	Second Law of Motion Apparatus	2.90	
5–1075	Micrometer Screw Attachment	3.25	
23–130	Scale Pan	.12	
23–128	Knife Edge Contact Piece	1.25	
23–142	Pine Rod, ½ × 1	.12	
23–143	Pine Rod, ½ × ½	.10	
15–305	Spring Balances, ½ K. (3 required)	3.00	
25–10 to 25–80	Center of Gravity Set.	$6.57	
25–100	Packard's Falling Body Apparatus	6.25	
25–230a	Pendulum Clamp	.95	
25–320	Double Cone and Plane	1.15	
26–30	Spiral Spring	1.95	
27–30	Demonstration Lever	1.95	
16–450	Interhooking Laboratory Weights	2.50	
27–45	Kittredge Lever Clamps (3 required)	.81	
27–141	Pulley Assortment	4.40	
27–290	Capstan and Arm	2.15	
27–325	Wheel and Axle	1.45	
27–390	Inclined Plane	1.60	
27–435	Inclined Plane Car	1.55	
29–60	Simple Truss	2.85	
16–500a–c and e–f	Unadjusted Iron Weights with Hanger (g)	2.00	
			$92.27
			$203.94

HYDRAULICS

31–45	Specific Gravity Group	$1.65	
31–55	Aluminum Block	.45	
31–145	Hare's Balancing Columns Apparatus	.85	
31–132	Specific Gravity Bottle	.33	
31–230	Demonstration Hydrometer	.25	
31–250a–e	Hydrometer Jars	3.80	
32–60	Pressure Gauge	2.50	
32–115	Pascal's Vase	6.75	
32–160	Mariotte's Bottle	3.75	
32–185	Liquid Level Communicating Tubes	.70	
32–230	Cartesian Diver	.80	
34–20	Hydraulic Press	1.65	
35–30	Model of Lift Pump	1.60	
35–32	Model for Force Pump	1.95	
			$27.03
			$230.97

PNEUMATICS

41–115	Boyle's Law Apparatus	$2.85	
42–20	Oil Sealed Pump	23.00	
41–150	Torricellian Tube and Mercury-Well	.80	
43–25	Bell Glass	1.00	
43–70	Bell Glass	.90	
43–150	Manometer	1.70	
43–200	Brass Coupling	.33	
43–230	Rubber Bag	1.15	
43–247	Water Hammer	.65	
43–255	Magdeburg Hemispheres	4.45	
45–10	Fortin School Barometer	8.90	
			$45.73
			$276.70

SOUND

51–85	Tuning Forks, Set of four	$5.00	
51–295	Organ Pipe	4.00	
53–115	National School Sonometer	4.50	
54–129	Chladni's Plate	1.00	
54–130	Chladni's Plate	1.00	
5–1085	Chladni's Plate Attachment	.60	
54–145	Lycopodium Powder	.45	

57–20	Double-Bass Bow	$1.50	
21–290	Rotating Mirror	3.15	
57–25	Resin	.10	
		——	$21.30
		———	$298.00

HEAT

60–20	Bunsen Burner	$0.25	
60–350	Hypsometer	2.25	
60–30	Bunsen Burner	.40	
60–400	Water Trap	.35	
61–150	Convectional Current Apparatus	1.15	
61–178	Hexagonal Conductometer	1.60	
63–15	Comparative Thermometer	.80	
63–38	Chemical Thermometer, double scale	1.35	
64–20	Thermoscope	2.25	
65–10	Cowen's Linear Expansion Apparatus	3.00	
65–18	Cowen Compensating Attachment	2.40	
65–75	Compound Bar	.95	
66–200	Specific Heat Apparatus	2.00	
67–50	Fire Syringe	1.75	
69–55	Locomotive Chart	2.25	
69–75	Working Steam Engine	6.25	
		——	$29.00
		———	$327.00

LIGHT

71–60	Rumford's Photometer	$4.25	
71–50	Student's Photometer	3.50	
71–350	Student's Optical Bench	1.25	
72–10	Glass Mirror	.12	
72–20	Concave and Convex Cylindrical Mirror	.50	
72–25	Concave and Convex Spherical Mirror	.50	
72–95	Multiple Image Apparatus	3.25	
73–10	Kolbe's Optical Disc	16.50	
74–75	Index of Refraction of Water Board	.75	
74–110	Demonstration Lenses	2.50	
74–190	Demonstration Achromatic Lens	.75	
74–280	Equilateral Prism	.33	
74–305	Right Angle Prism	.40	
74–430	Cast Hollow Prism	3.75	
74–480	Polyprism	.22	
77–85	Spectrum Chart	1.50	
77–160	Demonstration Spectral Apparatus	19.25	
77–350	Newton's Rings	1.50	
78–76	Iceland Spar	.70	
		——	$61.52
		———	$388.52

MAGNETISM

80–10	Lodestone	$0.40	
80–24	Horseshoe Magnet	.18	
80–35	Compound Horseshoe Magnet	1.70	
80–70	Bar Magnet	.50	
80–100	Hardened Steel Rods (4)	.10	
80–105	Soft Iron Bar	.20	
80–115	Magnetic Screens	.70	
80–120	Magnet Stirrup	.10	
80–160	Supporting Board	.40	
80–180	Iron Filings, 1 lb.	.20	
80–185	Filing Sifter	.15	
80–280	Magnetoscope	1.25	
80–305	Parallel Current Apparatus	1.70	
80–310	Vibrating Spiral	2.15	
81–12	Magnetic Needle	$0.60	
81–50	Demonstration Dip Needle	2.00	
81–75	Compasses (12)	1.40	
81–78	Magnetic Compass	.33	
		——	$14.06
		———	$402.58

STATIC ELECTRICITY

82–15	Friction Rod of Glass	$0.18	
82–25	Vulcanite Friction Rod	.42	
82–30	Wax Friction Rod	.10	
82–35	Celluloid Strip	.18	
82–60	Catskin	.75	
82–115	Cast Base Electrophorus	2.95	
82–160	Toepler-Holtz Machine Duty Free	21.00	
83–75	Pith Ball Electroscope	.60	
83–140	Gold Leaf Electroscope	1.70	
84–25	Discharger	1.25	
84–20	Proof Plane	.30	
84–90	Surface and Intensity Apparatus	3.80	
84–100	Faraday's Conical Net	1.65	
84–230	Demonstration Set	16.50	
85–10	Demonstration Leyden Jar	3.25	
85–15	Quart Leyden Jar	1.60	
86–15	Geissler Tubes	5.70	
87–10	X-Ray Tube	9.80	
87–100	X-Ray Stand	2.00	
87–125	Fluoroscope	8.25	
		——	$81.98
		———	$484.56

ELECTRICITY

90–20	D. C. C. Copper Wire No. 22 (1 lb.)	$0.90	
90–45 a	and e Spring Brass Wire (4 oz.)	.58	
90–70 a	and d Iron Wire (4 oz.)	.35	
57–10 a	and d Piano Wire (4 oz.)	1.50	
90–390	Single Contact Key	.80	
90–525	Electric Bell	.45	
91–42	Hall's Demonstration Battery Outfit	1.70	
91–90	Quart Daniell Cells (2)	1.30	
91–245	Student's Plunge Battery	5.00	
92–22	Oersted's Law Apparatus	2.25	
92–130	Gilley Induction Outfit	2.00	
92–160	Demonstration Electro-magnet	2.35	
93–175	Lecture Table Galvanometer	15.00	
93–650	Volt-Ammeter	6.50	
94–70	Resistance Coils	3.00	
94–170	B-P Switch Resistance Box	6.60	
94–440	Working Demonstration Wheatstone Bridge	5.80	
95–10	Faraday's Ring	3.25	
95–80	Demonstration Induction Coil	8.25	
97–10	Motor Parts	1.10	
97–60	Student's Motor Generator	3.50	
97–100	Motor-Dynamo Demonstration Apparatus	3.85	
98–25	Combination Keys and Sounders (2)	5.00	
98–100	Demonstration Receiver	1.45	
99–30	Osborne's Electrolysis Apparatus	4.85	
99–50	Carbon Electrodes (2)	1.10	
99–55	Copper Electrodes (2)	1.10	
		——	$89.53
	Total for Apparatus	———	$574.09
	Cases		6.25
	Total		$580.34

Net Price f. o. b. Boston **$532.00**

PHYSICAL APPARATUS GROUP "D"

In the making up of this list it has been taken for granted that the entire Syllabus as treated in the average high school text is to be discussed with class room demonstration and that the instruments selected for each point are such as to make a most complete and satisfactory demonstration course.

LABORATORY HARDWARE

5-995 Lecture List "B" Bases, Support Rods and Clamps . . $173.00

MEASUREMENTS

10-10 Meter Chart $2.50
10-20 Liter Block 3.00
10-35 Liter Case 3.00
10-50 Cubic Foot Block 7.65
10-60 Wooden Cubes 3.30
10-75 Vernier Caliper Model 2.75
10-80 Vernier Arc Model 9.00
10-85 Meter Stick 1.50
10-100 Liquid Measures 4.90
11-10 Meter Stick 30
11-177 Standard Meter . . Duty Free 21.50
11-145 Comparing Scale 20
12-97 Micrometer Caliper 7.15
12-175 Vernier Caliper 4.90
12-205 Spherometer 5.90
12-277 Wire Gauge 2.20
13-175 Students' Slide Rule 50
14-60 Angle-graph 6.15
14-110 Balance Level 1.00
14-130 Plumb Bob 12
15-110 Demonstration Balance Duty Free 54.00
15-375 Rintoul's Dynamometer . . . 2.50
16-327 Weights, 1-1000 grams 3.50
17-10 Clock 55.00
17-165 Stop Clock . . . . Duty Free 9.80
17-300 Speed Indicator 1.00
18-40 Triangle Demonstration Apparatus 1.90
18-50 Circle Area Demonstration Apparatus 2.10
18-125 Models of Glass 4.75
19-61 Pantograph 90
19-75 Drawing Instruments 4.35

——— $227.32
——— $400.32

MECHANICS

20-10 Porosity Apparatus $1.70
20-95 Glass Disc 65
20-100 Film Demonstration Apparatus .90
20-115 Bologna Phials (Lot of 10) . . 1.50
20-117 Adhesion Disc 50
20-130 Tapering Capillary Tubes . . .35
20-160 Capillary Tubes on Stand Duty Free 6.15
20-220 Osmosis Apparatus 3.90
20-250 Incompressibility of Liquids Apparatus 3.75
21-30, 21-35 D. C. Rotator or A. C. Rotator 37.00
21-60 Centrifugal Hoop 2.20
21-120 Heat by Friction Apparatus . 2.00
21-175 Globe 2.85
21-185 Watt's Governor 4.50
21-190 Valve Regulator 4.50
21-210 Color Discs $2.00
21-220 Combination Disc 3.90
21-265 Siren Disc 3.15
21-270 Air Impulse Attachment . . . 2.95
21-280 Crova's Disc and Shield . . . 2.80
21-300 Revolving Mirror 8.75
21-305 Arago's Apparatus 6.15
21-340 Gyroscope Outfit 17.45
22-110 Combination Set of Balls . . . 4.90
22-135 Impact Apparatus 2.90
22-145 Impact and Reflection Apparatus 6.65
22-180 Collision Ball Apparatus . . . 14.75
22-225 Second Law of Motion Apparatus 2.90
23-50 Torsion Pendulum 14.60
23-62 Torsion System 1.85
23-102 Inertia System 1.85
23-128 Knife Edge Contact Piece . . 1.25
23-142 Pine Rod, ½ × 1 inch 12
23-143 Pine Rod, ½ × ½ inch 10
23-211 Breaking Strength of Wires Apparatus 5.00
15-305 Spring Balances, ½ K. (3 required) 3.00
24-15 Support Board 2.20
25-100 Packard's Falling Body Apparatus 6.25
25-120 Guinea and Feather Tube . . 6.75
25-235 Pendulum Illustration . . . 3.45
25-260 Reversible Pendulum 3.95
26-20 Wave Apparatus 10.40
27-30 Demonstration Lever 1.95
16-450 Interhooking Laboratory Weights 2.50
27-45 Kittredge Lever Camps, Per set of three 81
27-143 Pulley Assortment 9.00
27-242 Differential Pulley Hoist Duty Free 8.25
27-290 Capstan and Arm 2.15
27-325 Wheel and Axle 1.45
27-410 Pratt Institute Inclined Plane . 7.35
27-412 Inclined Plane Roller 3.15
27-475 Model of Wedge 8.25
29-100 Roof Truss 4.25
29-40 Spring Dynamometer 2.75
28-80 Spring Dynamometer 1.25
16-500a-c and e-f Unadjusted Iron Weights, with hanger G . 2.00

——— $267.58
——— $667.90

HYDRAULICS

31-45 Specific Gravity Group $1.65
31-55 Aluminum Block 45
31-67 Specific Gravity Specimens . . .95
31-145 Hare's Balancing Columns Apparatus 85
31-131 Specific Gravity Bottle 1.00
31-150 Specific Gravity Plummets Duty Free 9.85
31-245 Tralles Hydrometer Duty Free 9.65
31-250a-e Hydrometer Jars (Three of each) 11.40

32–60	Pressure Gauge	$2.50	
32–100	Pascal's Vases	18.00	
32–150	Torricellian Law Apparatus	7.90	
32–180	Liquid Level Apparatus	3.30	
32–230	Cartesian Diver	.80	
34–10	Hydraulic Power Press	28.50	
34–20	Hydraulic Press	1.65	
35–55	T-Beam Lift and Force Pump	19.45	
36–50	Reaction Gas and Flame Wheel	2.50	
37–30	Model of Water Turbine Duty Free	13.50	
38–20	Water Motor	9.80	
			$143.70
			$811.60

PNEUMATICS

40–22	Baroscope Globe and Bell in Vacuo	$5.40	
40–17	Baroscope Balance	3.75	
40–90	Osmosis Bulb	.70	
41–20	Gas Pressure Apparatus	5.80	
41–110	Boyle's Law Apparatus	9.00	
42–25	Oil Sealed Pump	45.00	
41–150	Torricellian Tube and Mercury Well	.80	
43–80	Bell Glass	3.85	
43–35	Bell Glass	1.65	
43–37	Bell Glass	2.60	
43–70	Bell Glass	.90	
43–145	Manometer	4.50	
43–200	Brass Coupling	.33	
43–230	Rubber Bag	1.15	
43–250	Water Hammer	2.15	
43–255	Magdeburg Hemispheres	4.45	
43–270	Model of Diving Bell	9.25	
45–15	Fortin School Barometer	14.75	
			$116.03
			$927.63

SOUND

51–86	Tuning Forks Duty Free	$12.75	
51–137	Electro-Synchronism Recording Fork	9.50	
51–190	Sympathetic Tuning Fork Duty Free	13.50	
51–205	Morse Sympathetic Vibration Apparatus	8.25	
51–240	Galton's Whistle	8.75	
51–285	Organ Pipes Duty Free	18.75	
51–290	Organ Pipe	4.00	
52–10	Reflectors	17.50	
52–30	Sound Lens	9.80	
52–80	Interference Tubes	1.35	
53–125	Vertical Wall Form Sonometer	11.50	
53–200	Resonance Apparatus	8.50	
54–131	Chladni's Plate	1.40	
54–132	Chladni's Plate	1.40	
54–145	Lycopodium Powder	.45	
57–20	Double Bass Bow	1.50	
54–200	"Sonograph"	25.00	
55–45	Glass Helmholtz Resonator	6.25	
57–25	Resin	.10	
			$160.25
			$1087.88

HEAT

60–40	Semi-Blast Wynne Burner	$1.50	
60–350	Hypsometer	2.25	
60–30	Bunsen Burner	.40	
60–400	Water Trap	.35	
61–11	Crooke's Double Radiometer	4.00	
61–70	Absorption Screen	3.90	
61–100	Leslie's Cube	1.65	
61–160	Convectional Current Apparatus	$1.90	
61–175	Harcourt Vertical Conductometer	3.90	
62–62	Vapor Tension Tube	3.00	
62–150	Wollaston Cryophorus	1.40	
63–15	Comparative Thermometer	.80	
63–38	Chemical Thermometer, double scale	1.35	
64–15	Thermoscope	7.50	
64–57	Air Thermometer Bulb	1.75	
64–100	Thermopile	14.50	
65–10	Cowen's Linear Expansion Apparatus	3.00	
65–18	Cowen Compensating Attachment	2.40	
65–80	Compound Bar	4.00	
65–130	Breaking Apparatus	9.50	
66–200	Specific Heat Apparatus	2.00	
67–50	Fire Syringe	1.75	
69–50	Model of Steam Engine	24.50	
69–122	Steam and Electric Power Plant	88.75	
			$186.05
			$1273.93

LIGHT

70–22	Heliostat Duty Free	$54.00	
71–10	Ritchie Photometer	9.75	
71–300	Bunsen Photometer, complete	16.35	
71–276	Selenium Cell	7.50	
71–190	Screen with apertures	3.30	
71–195	Adjustable Slit	3.40	
71–200	Large Screen Holder	.75	
71–205	Small Screen Holder	.65	
71–225 to 71–235	Screens	1.10	
71–210	Conjugate Foci Box	.90	
72–12	Plane Mirror	.20	
72–35	Convex Mirror	1.25	
72–37	Concave Mirror	1.25	
72–90	Multiple Reflection Apparatus	7.50	
72–140	Total Reflection Apparatus Duty Free	10.50	
73–10	Kolbe's Optical Disc	16.50	
73–75	Refraction Tank	3.90	
73–80	Polarized Light Attachment	8.25	
74–90	Pratt Institute Index of Refraction Apparatus	1.90	
74–107	Demonstration Lenses	7.50	
74–190	Demonstration Achromatic Lens	.75	
74–200	Prismatic Lenses	2.50	
74–210	Mounted Condensing Lens	5.90	
74–434	Hollow Glass Prism Duty Free	7.50	
74–452	Mounted Equilateral Prism	6.90	
74–455	Mounted Total Reflection Prism	6.25	
74–460	Weinhold's Demonstration Prism Duty Free	17.25	
75–153	Telescope Models Duty Free	18.00	
77–75	Spectrum Chart Duty Free	36.50	
77–95	Reflected and Transmitted Light Apparatus	4.25	
77–100	Von Nardroff Color Apparatus	32.00	
77–160	Demonstration Spectral Apparatus	19.25	
77–270	Double Absorption Trough	6.25	
74–438	Wedge-shaped Absorption Troughs Duty Free	5.20	
77–300	Fresnel's Interference Mirrors Duty Free	14.75	
77–305	Fresnel's Bi-prism Duty Free	8.25	
77–352	Newton's Rings Duty Free	13.50	
78–75	Iceland Spar	1.50	
78–87	Adjustable Tourmaline Tongs Duty Free	11.40	
78–95c	Nicol's Prism	4.80	
78–140	Unannealed Glass Specimens Duty Free	12.00	
			$391.15
			$1665.08

MAGNETISM

80–11	Lode Stone	$0.80
80–14	Supporting Stirrup	.65
80–24	Horseshoe Magnet	.18
80–26	Horseshoe Magnet	.48
80–35	Compound Horseshoe Magnet	1.70
80–61	Bar Magnet	.60
80–70	Bar Magnet	.50
80–85	Breaking Magnets. Set of two	.44
80–87	Glass Tube and Steel Filings	.50
80–90	Magnetized Steel Disc	.55
80–100	Hardened Steel Rods. Set of four	.10
80–105	Soft Iron Bar	.20
80–106	Soft Norway Iron Rod	.40
80–115	Magnetic Screens. Set of six	.70
80–120	Magnet Stirrup	.10
80–150	Molecular Magnet Model Duty Free	9.25
80–225	Lines of Force Apparatus Duty Free	7.80
80–232	Lines of Force Apparatus Set of six	8.50
80–180	Iron Filings, 1 pound	.20
80–185	Filings Sifter	.15
80–265	Spring Magnetometer Duty Free	7.50
80–300	Magnetic Pole Rotation Apparatus	5.50
80–305	Parallel Current Apparatus	1.70
80–310	Vibrating Spiral	2.15
81–10	Magnetic Needle	1.25
81–15	Astatic Needle	2.00
81–50	Demonstration Dip Needle	2.00
81–55	Dipping Needle	3.30
81–75	Compasses. Set of twelve	1.40
81–95	Magnetic Compass	1.65
		$62.25
		$1727.33

STATIC ELECTRICITY

82–10	Amber Specimen	$0.95
82–20	Glass Friction Rod	.55
82–25	Vulcanite Friction Rod	.42
82–30	Wax Friction Rod	.10
82–35	Celluloid Strip	.18
82–65	Catskin	1.25
82–110	Lecture Table Electrophorus	9.25
83–100	Pith Ball Electroscope	3.25
83–200	Cast Drum Gold Leaf Electroscope	6.25
84–10	Insulating Stool	2.50
84–15	Insulating Stand	2.50
84–30	Discharger	2.75
84–20	Proof Plane	.30
84–55	Induction Sphere	2.75
84–60	Induction Cylinder	9.25
84–70	Hollow Induction Cylinder	2.70
84–85	Biot's Hemispheres	2.25
84–90	Surface and Intensity Apparatus	3.80
84–100	Faraday's Conical Net	1.65
85–10	Demonstration Leyden Jar	3.25
85–40	Luminous Leyden Jar	3.15
85–100	Dissectible Plate Condenser	9.60
86–40	Lecture Table Geissler Tubes, 14 in.	14.80
86–66	Geissler Tubes	2.25
86–75	Unequally Evacuated Geissler Tubes	8.90
86–150	De La Rives Apparatus	5.90
86–160	Vacuum Tube	7.50
86–165	Vacuum Tube	5.75
87–60	X-Ray Tube	20.40
87–100	X-Ray Stand	$2.00
87–140	Fluoroscope	10.00
		$146.15
		$1873.48

ELECTRICITY

90–45a and e	Spring Brass Wire (4 oz.)	$0.58
90–70a and d	Iron Wire (4 oz.)	.35
57–10a and d	Piano Wire (4 oz.)	1.50
90–154	Artificial Light Circuit	8.75
90–187	Connectors (2)	1.60
90–177	Connectors (4 pairs)	.80
90–179	Connectors (1 pair)	.30
90–180	Connectors (1 pair)	.40
90–390	Single Contact Key	.80
90–392	Double Contact Key	1.80
90–525	Electric Bell	.45
91–15	Gilley Skidmore Battery Outfit	2.40
91–75	Gallon Daniell Cells (2)	3.30
91–300	Dry Cells (6)	1.50
92–35	Oersted's Law Apparatus	4.00
92–50	Ampere's Frame	11.00
92–75	Parallel Current Repulsion Coils	7.75
92–160	Demonstration Electro-magnet	2.35
92–175	Helix and Separable Magnetic Circuit	2.90
92–185	Solenoid Magnet	1.70
92–195	Mounted Electro-magnet	7.50
93–130	Lecture Table Galvanometer	35.00
93–230	Self-Leveling D'Arsonval Galvanometer	32.00
93–460	Lamp and Scale	11.00
93–600	Triple Range Voltmeter and Ammeter	20.00
94–90	Resistance Board	4.50
94–170	B-P Switch Resistance Box	6.60
94–280	Ziegler Bridge and Box	34.75
94–355	Universal Resistance Frame	25.00
94–425	Hydro-dynamic Wheatstone Bridge . . . Duty Free	34.50
94–440	Working Demonstration Wheatstone Bridge	5.80
95–30	Dissectible Transformer	11.25
95–95	Demonstration Ruhmkorff Coil Duty Free	37.50
95–310	Separately Mounted Resonant Leyden Jars	14.50
95–340	Bi-polar High Frequency Coil	140.00
95–375	High Frequency Phenomena Apparatus	35.00
95–490	Multiple Range Electrolytic Rectifier	38.00
97–100	Motor-Dynamo Demonstration Apparatus	3.85
97–160	Page Motor Apparatus	8.50
97–165	Page Motor Apparatus	9.75
98–10	Telegraph Keys (2)	3.80
98–15	Improved Sounders (2)	5.00
98–20	Telegraph Relays (2)	6.80
98–100	Demonstration Receiver	1.45
98–125	Microphone	5.75
99–30	Osborne's Electrolysis Apparatus	4.85
99–50	Carbon Electrodes (2)	1.10
99–55	Copper Electrodes (2)	1.10
99–200	Simple Electric Furnace Duty Free	26.00
		$625.08
	Total for apparatus	$2498.56
	Cases	28.50
	Total	$2527.06

Net Price f. o. b. Boston $2248.00

PHYSICAL GLASSWARE

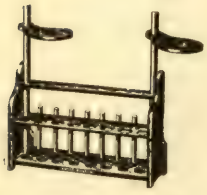
Nos. 1348 b to f

No. 1414 No. 1417

No. 1424 No. 1427

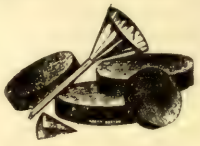
No. 1832 No. 1826

No. 1528 No. 1524


No. 2167 b

No. 1360

No. 2360


No. 1852 No. 2124

No. 1776

No. 1362

No. 1660

Nos. 1614 a to e

No. 2134

No. 1926

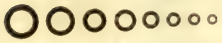
Nos. 1928 a to b

Nos. 1664 a to b

No. 1698

No. 1724

No. 1684


No. 2354

No. 1690 a

No. 2200

No. 1344

1019 **ASBESTOS BOARD,** best quality, $\frac{3}{32}$ inch thick . . . . . Per square foot **$0.2**

1344 **IRON SAND BATH,** diameter 6 inches . . . . . **.15**

1348 **BATH** for water or oil, copper, with concentric ring cover.

	b	d	f
Diameter	5	6	8
Each	**$0.95**	**1.25**	**1.90**

1360 **BEAKERS,** low wide Griffin form with lip, supplied in nests or separately as follows:—

	1	2	3	4	5	6	7	8
Capacity	75	100	200	300	400	600	800	1000 cc.
Each	**$0.12**	**.13**	**.16**	**.18**	**.20**	**.25**	**.30**	**.40**

1362 **BEAKERS,** wide, usual form, without lip, in nests or separately as follows:—

	1	2	3	4	5	6	7	8
Capacity	75	100	200	300	400	600	800	1000 cc.
Each	**$0.10**	**.12**	**.15**	**.18**	**.20**	**.25**	**.30**	**.40**

1417 **BOTTLES,** Prescription, wide mouth, without glass stopper.

	a	b	c	d	e	f
Capacity	1	2	4	8	16	32 ounces
For Cork No.	10	14	19			
For A. R. Stopper No.	21	25	30	33	40	47
Per Hundred	**$2.00**	**3.00**	**4.00**	**6.00**	**9.00**	**15.00**

1427 **BOTTLES,** Salt Mouth, with wide mouth and glass stopper.

	a	b	c	d	e	f
Capacity	1	2	4	8	16	32 ounces
Per Hundred	**$7.00**	**7.50**	**8.00**	**12.00**	**18.00**	**24.00**

1436a **BOTTLE,** aspirator, with side tubulature, 1 gallon **$1.30**

1437 **BOTTLE,** aspirator, with side tubulature, made for rubber tubing, 1 quart . . . . . **.90**

1466 **BOTTLE,** Woulff, with two necks, 8-ounce . . . . . **.45**

1468 **BOTTLE,** Woulff, with three necks, 8-ounce . . . . . **.48**

1480 **BOTTLE BRUSH,** for cleaning bottles, beakers, etc. . . . . **.20**

1484 **TEST TUBE BRUSH,** with bristle end . . . . . **.10**

1524 **MOHR'S BURETTE,** arranged for pinchcock, 25 cc. (not including pinchcock and tip) . . . . . **.65**

1524d ——, same as above, 50 cc. **1.25**

1528 **GEISSLER BURETTE,** with stopcock, 25 cc. **1.25**

1528c ——, same as above, 50 cc. **1.85**

1614 CASSEROLES, Royal Berlin form, durable, thin, with porcelain handles and flat bottoms, glazed.

No.	00	0	2	3	4
Capacity	125	190	375	625	1000 cc.
Each	**$0.40**	**.50**	**.85**	**1.40**	**1.75**

1640 CLAMP, small, for ring stand, jaws open to 1½ inches **$0.40**
1658 TEST TUBE CLAMP, wooden, with spring . . . . . **.15**
1660 HOFFMAN'S SCREW PINCHCOCK . . . . . **.20**
1664a MOHR'S SPRING PINCHCOCK, medium . . . . . **.12**
1664b ——, same as above, large . . . . . **.15**
1684 CORKS, superior quality, medium taper:—

No.	1	2	3	4	5	6	7	8
Size	5/16	3/8	7/16	1/2	9/16	5/8	11/16	¾ inch
Per hundred	**$0.36**	**.36**	**.42**	**.48**	**.64**	**.72**	**.96**	**1.20**

No	9	10	11	12	13	14	15	16
Size	¾	13/16	⅞	15/16	1⅛	1	1 1/16	1 3/16 inch
Per hundred	**$1.40**	**1.80**	**1.90**	**2.05**	**2.30**	**2.50**	**2.80**	**3.60**

No.	17	18	19	20	22	24	26
Size	1¼	1¼	1 5/16	1⅜	1½	1 9/16	1¾ inches
Per hundred	**$4.10**	**4.50**	**4.90**	**5.50**	**8.00**	**10.50**	**10.90**

1690a CORK BORERS, in set of 6, sizes to ½ inch . . . . . Per set **$1.00**
1698 CRUCIBLES, porcelain, the best ware, thin and durable; will stand great heat. A crucible well adapted to the general work in the laboratory.

No.	00	0	1	2	3	4	5
Diameter	1¼	1½	1¾	2	2½	3	3½ inches
Capacity	13	14	25	45	80	140	280 cc.
Each	**$0.15**	**.25**	**.25**	**.35**	**.45**	**.50**	**.60**

1724 CYLINDERS, graduated, with lip, broad base.

	a	b	c	d	e	f	g
Capacity	10	25	50	100	250	500	1000 cc.
Each	**$0.25**	**.30**	**.35**	**.50**	**.80**	**1.00**	**1.50**

1766 CRYSTALLIZING DISHES.

	a	b	c	d	e
Diameter	2	3	4	5	6 inches
Each	**$0.11**	**.14**	**.20**	**.30**	**.40**

1768 DOUBLE DISHES.

	a	b	c	d	e	f	g	h
Diameter	4	5	6	7	8	9	10	12
Each	**$0.12**	**.14**	**.17**	**.18**	**.20**	**.22**	**.25**	**.30**

1776 EVAPORATING DISHES, made of best quality porcelain, thin, uniform and durable.

No.	00	0	1	2	3	4
Diameter	7	8	8½	9	10	11 cm.
Capacity	65	85	110	140	165	250 cc.
Each	**$0.18**	**.20**	**.30**	**.35**	**.40**	**.45**

No.	5	6	7	8	9	10
Diameter	12	14.5	18	21.5	26.5	31 cm.
Capacity	290	475	810	1320	2585	4000 cc.
Each	**$0.55**	**.75**	**.90**	**1.20**	**1.75**	**2.75**

1826 FLASKS, Erlenmeyer form; will withstand much rough usage; cannot be readily tipped over; easily washed.

	a	b	c	d	e
Capacity	60	125	250	500	1000 cc.
Each	**$0.08**	**.10**	**.14**	**.20**	**.30**

1832 FLASKS, spherical, flat bottom, finest Bohemian glass of perfect form.

	a	b	c	d	e	f	g	h
Capacity	25	50	100	250	500	1000	2000	4000
Each	**$0.07**	**.08**	**.09**	**.14**	**.20**	**.30**	**.50**	**1.00**

1848 FORCEPS, steel, for handling phosphorus, potassium, etc. in the laboratory **$0.08**
1852 FUNNELS, Bunsen's, stem cut at an angle of 60°.

	a	b	c	d	e	f	g	h
Size	2	2½	3	4	5	6	8	10 inches
Each	**$0.10**	**.12**	**.14**	**.18**	**.20**	**.25**	**.45**	**.85**

1894 GAS STOPCOCKS, brass, special, for gas.

	a	b	c
Regular Pipe Trade Term	1–8	1–4	1–2
Each	**$0.45**	**2.00**	**6.00**

1902 GAS STOPCOCK, TURRET or DISTRIBUTOR, 4 cocks **$2.50**
1926 GAUZE, with asbestos in the mesh; very successful for slow evaporation . . . . . Per hundred **15.00**
1928 GAUZE, iron, thick and durable quality, for use in heating chemical glassware above the boiling point . . . . Per square foot **.30**
1928a ——, same as above, but in sheets 4 by 4 inches square . . . . . Per hundred **5.00**
1928b ——, same as above, but in sheets 6 by 6 inches square . . . . . Per hundred **8.00**
1936 GLASS CUTTING STEEL WHEEL . . . . . **.18**
2036 LABELS, gummed, with red border, No, 201, size 1½ by 2½ inches . . . . . Per box **.10**
2124 FILTER PAPER, best German qualitative paper . . . . . Per ream **7.00**
2125 FILTER PAPER.

	a	b	c	d	e	f
Size	3	4	5	6	8	10 inches
Per package	**$0.12**	**.15**	**.18**	**.20**	**.35**	**.50**

2134 PIPETTE or MEDICINE DROPPER, straight **$0.05**
2164 PRESS FOR CORKS, flat . . . . . **.25**

2167a TEST TUBE RACK, wire **$0.40**
2167b ——, wood, according to C. W. Irish of Lowell . . . . . **.50**
2186 ANTIMONY RUBBER STOPPERS, best antimony rubber.

Sizes 11 and 13 furnished either solid or with one hole.
Sizes 43, 47 and 51 furnished solid only.
Other sizes furnished solid and with one or two holes.

Size, millimeters	11	13	15	17	19	21	23	25
Per hundred	**$3.00**	**4.00**	**5.00**	**6.00**	**7.00**	**9.00**	**11.00**	**14.00**

Size, millimeters	28	30	33	37	40	43	47	51
Per hundred	**$15.00**	**20.00**	**23.00**	**31.00**	**40.00**	**46.00**	**48.00**	**56.00**

2200 RUBBER TUBING, best antimony stock, regular thickness of wall.

Inside Diameter	a 1/8	b 3/16	c 1/4	d 3/8	e 1/2	f 3/4 inches
Per foot	**$0.06**	**.08**	**.12**	**.17**	**.26**	**.40**

2256 RING or RETORT STAND, with tripod base and rod, small size **$0.35**
2258 ——, same as above, medium size . . . . . **.50**
2260 ——, same as above, large size . . . . . **.75**
2266 RING or RETORT STAND. with tripod base and rod, small size, supplied with two rings . . . . . **.45**
2268 ——, same as above, medium size, supplied with three rings . . . . . **.65**
2270 ——, same as above, large size, supplied with four rings **1.00**
2292 RINGS, for small and medium stands.

Size	a 2	b 3	c 4 inches
Each	**$0.15**	**.18**	**.21**

2296 FILTER STAND, funnel arms for same, designed at Harvard **$0.40**
2360 TEST TUBES.

	a	b	c	d	e	f	g	h
Length	4	4	5	5	6	6	6	8 inches
Diameter	1/2	5/8	5/8	3/4	5/8	3/4	1	1 inch
Per dozen	.15	.16	.20	.25	.25	.30	.35	.60
Per gross	**$1.50**	**1.60**	**1.95**	**2.30**	**2.40**	**2.75**	**3.40**	**6.00**

2508 BRASS T-TUBE **$0.25**
2510 GLASS T-TUBES.

Size	a 1/8	b 3/16	c 1/4	d 3/8
Each	**$0.05**	**.07**	**.10**	**.14**

2514 BRASS Y-TUBE **$0.50**
2516 LEAD Y-TUBE . . . . . **.27**
2518 GLASS Y-TUBES.

Size	a 1/8	b 3/16	c 1/4	d 3/8
Each	**$0.05**	**.07**	**.10**	**.14**

2530 GLASS TUBING, hardest Bohemian, 8 millimeters diameter . . . . . Per pound **$0.90**
2532 ——, same as above, 28 millimeters diameter . . . . . Per pound **.75**
2534 GLASS TUBING, best German soft glass, for connections, etc.

Outside Diameter	a 4 1/2	b 5	c 5 1/2	d 6	e 6 1/2	f 7	g 8	h 9	10 mm.
Per pound	**$0.50**	**.50**	**.50**	**.50**	**.50**	**.50**	**.50**	**.50**	**.50**

2556 WATCH GLASSES, thin, well annealed.

Diameter	a 1	b 1 1/2	c 2	d 2 1/2	e 3	f 3 1/2	g 4	h 5	i 6 inches
Per dozen	**$0.20**	**.20**	**.20**	**.45**	**.45**	**.65**	**.65**	**1.45**	**2.00**

TOOLS

We list below various tools which will be found of service in the laboratory.

200–10	**AUGUR BITS,** set of thirteen, from ¼ to 1 inch		$5.00
200–15	**BIT BRACE**		.75
200–20	**BLOCK PLANE** of iron, 5½ inches long		.50
200–25	**CHISEL,** best Sheffield steel, one inch wide		.50
200–30	**CLAW HAMMER,** first quality of cast steel, weight one pound		.60
200–35	**CLAW HAMMER,** nickel-plated, ordinary grade		.45
200–40	**COLD CHISEL,** ½ inch		.20
200–45	**CORK SCREW,** large size		.25
200–50	**FILE,** flat, 8 inches long		.20
200–55	**FILE,** half round, 8 inches long		.20
200–60	**FILE,** round, 8 inches long		.18
200–62	**FILE,** triangular, 8 inches long		.20
200–65	**GIMLET,** large size, 5 inches long		.20
200–70	**HACK SAW,** consisting of malleable steel frame and saw blade		.50
200–75	**HACK SAW BLADES,** 8 inch, to fit the above frame	Per dozen	.40
200–80	**OIL STONE,** in wooden box, 7 inches long		1.00
200–85	**PLIERS,** with side cutting blade, 5 inches		.40
200–90	**SAW, CROSS-CUT,** 26 inches long		1.50
200–95	**SAW, RIP,** 26 inches long		1.65
200–100	**SAW, KEY-HOLE**		.25
200–105	**SCREW DRIVER,** instrument size, with small sharp blade		.50
200–110	**SCREW DRIVER,** heavy, 8 inch		.25
200–115	**SHEARS,** metal cutting, 2½ inch blade		.75
200–120	**WRENCH (MONKEY WRENCH),** 8 inches long		.60

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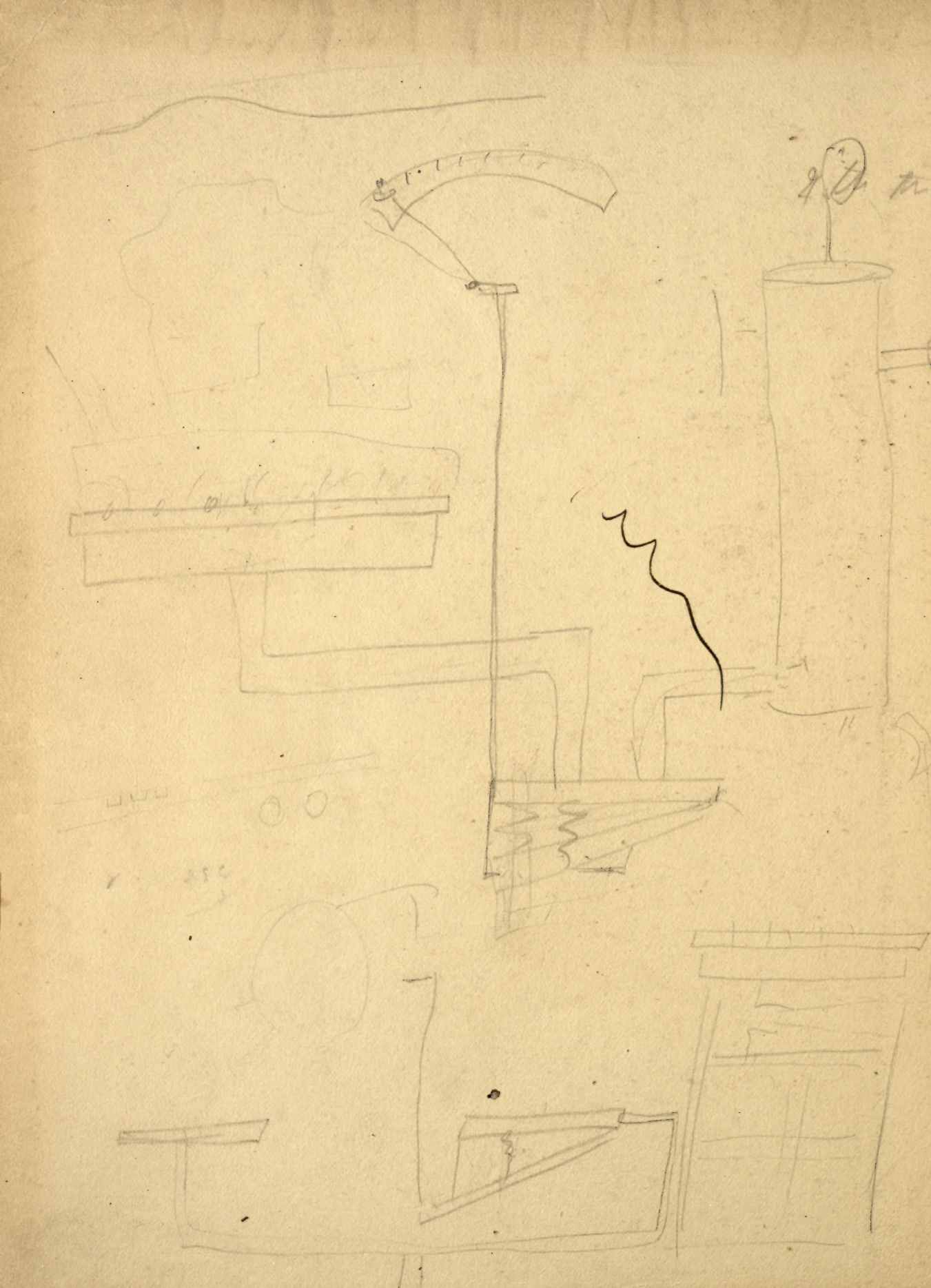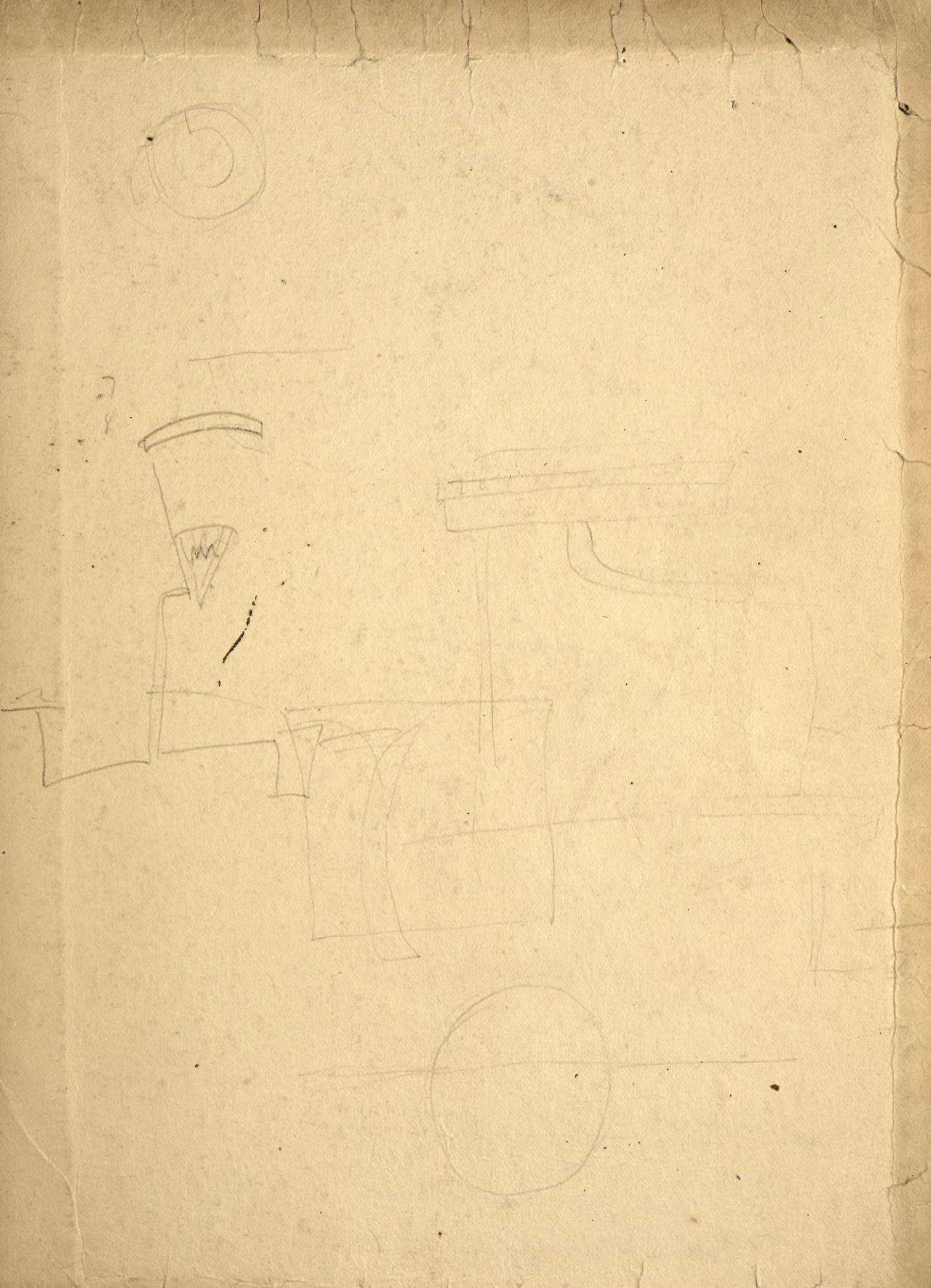
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